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THE two following important Papers have recently been read before the Royal Society. We publish them *in extenso* and, through the kindness of the authors, have been enabled to give full illustrations of the apparatus employed in carrying out the experiments, in addition to those given with the papers.

ON THE CONVERSION OF RADIANT ENERGY INTO SONOROUS VIBRATIONS.

By WILLIAM HENRY PREECE.

(Read before the Royal Society, March 10, 1881.)

MESSRS. GRAHAM BELL AND SUMNER TAINTER* have shown that, under certain conditions, intense rays of light, if allowed to fall with periodic intermittence upon thin discs of almost every hard substance, will set up disturbances in those discs, corresponding to this periodicity, which result in sonorous vibrations. Mr. Bell† has subsequently shown that such effects are not confined to hard substances, but that they can be produced by matter in a liquid or gaseous form.

These discoveries have elicited a considerable amount of interest, and have led to the inquiry whether the sonorous effects are due, as the discoverers themselves surmised, to *light*, or as the President of the Royal Society, Professor Tyndall, and others have suggested, to radiant *heat*.

Messrs. Bell and Tainter have partially answered this question by showing that the disturbances are not necessarily due to light, for they found that sheets of hard rubber or *ebonite*—a substance opaque to light—do not entirely cut off the sounds, but allow certain rays to pass through, which continue the effect. M. Mercadier, who has studied the subject with great care,‡ has shown that the effects are confined to the red and ultra-red rays. Moreover, Mr. Bell has shown that gases, such as sulphuric ether, which Professor Tyndall has proved to be highly absorbent of heat rays, while they are transparent to light rays, are remarkably sensitive to this intermittent action. Dr. Tyndall has more recently read a paper before the Society§ proving that these sonorous effects are a function of all gases and vapours absorbing radiant heat, and that the intensity of the sounds produced is a measure of this absorption.

The negative proof of Messrs. Bell and Tainter can be rendered positive if it can be shown that ebonite is *diathermanous*. The author provided himself with several sheets of different substances, and a sensitive radiometer. A standard candle and a lime-light were used as sources of energy, the former being fixed four inches and the latter four feet from the radiometer, which was carefully screened from all disturbing influences but that of the source. The number of revolutions made by the radiometer per minute was counted, and the average of several observations was taken. The following is the result, and the numbers indicate the relative diathermancy of the substances used to the source of light employed :—

1. Experiments on Diathermancy.

Material.	Source of radiant energy.	
	Candle, 4 ins.	Lime-light 4 ft.
Air	100	100
Ebonite, No. 1 (·4 millim.)	60	91
,, ,, 2 (·9 millim.)	24·3	79·3
,, ,, 3 ,,	24·3	79·3
,, ,, 4 ,,	24·3	68·2
,, ,, 5 ,,	24·3	68·2
,, ,, 6 (·4 millim.)	0	9
India-rubber (native)	44·3	61·4
,, (prepared)	60	54·5
,, (vulcanised)	0	0
,, (and ozokerit)	0	6·8
Ozokerit (·5 millim.)	0·14	9
Carbon (2 millims.)	0	
Carbonised paper	0	
Blue foolscap	0	4·5
White note paper	0	4·5
Thin foreign	0	
Tissue	0·6	

Ebonite was, however, proved to be very variable, and while some pieces proved to be as diathermanous as rocksalt, others of the same thickness were found to be quite athermanous.

Ebonite therefore, being sometimes diathermanous and opaque, it is clear that the sonorous vibrations of Bell and Tainter are the result of disturbances produced by some thermic action rather than by any luminous effect. Several other experiments made by them confirm this conclusion, notably those made upon crystals of sulphate of copper, a substance which Mr. Crookes has shown to be highly opaque to rays of low refrangibility.*

Now, the questions arise, is this thermic action, expansion and contraction of the mass due to its absorption of heat? Or is it a disturbance due to molecular pressure similar to that which produces the rotation of the radiometer? Or is it due to some other cause?

The argument against the first assumption when applied to hard discs, is that *time* is a material element in such actions, and that the rate of cooling of warmed diaphragms is too slow to admit of such effects. Lord Rayleigh† has questioned the validity of this argument, and has shown that if the radiating power of the body experimented on were sufficiently high a slow rate of cooling would be favourable to rapid fluctuations of temperature. It became desirable to test this point experimentally. The following apparatus was constructed for the purpose.

AB, fig. 1, is a thin strip or wire 6 centims. in length of the substance to be examined, fixed to a platinum "make and break," M, and adjusted to a lever, S, round whose axis is fastened a silk thread, the end of which is attached to the strip or wire at A, and whose position could be adjusted by a screw, C. Any variation of

* American Association for the Advancement of Science. Boston, August 27, 1880.
† *Journal of the Society of Telegraph Engineers*, December 8, 1880.
‡ *Comptes Rendus*, December 6, 1880.
§ *Proc. Roy. Soc.*, vol. xxxi., p. 307.

* *Phil. Trans.*, vol. clxix., § 268.
† *Nature*, January 20, 1881.

tension due to expansion or contraction of the wire would produce intermission in the electric currents passing through the telephone, T, which, if periodically produced, would result in sonorous vibrations in the telephone. Heat from various sources and at various distances, from bright lime-light to dull heat from hot metallic surfaces, was allowed to fall through rotating vanes intermittently on AB; but notwithstanding every precaution, and the many materials used, not more than six interruptions per second could be produced, although the system was beautifully sensitive to the smallest changes of temperature.

The best effect was obtained when AB was a thin ebonite wire about ·5 millim. in diameter, and 6 centims. in length.

It was evident from these experiments that the sonorous effects of hard discs could not be explained by the change of volume due to the impact of heat rays, and their absorption by the mass of the disc.*

Is the action then due to molecular pressure similar to that which produces the rotation of the radiometer?

It is quite true that the radiometer effect is one visible only in very high exhaustions, but Mr. Crookes (*Phil. Trans.*, vol. clxix., § 220) detected "the existence of molecular pressure when radiation falls on a black surface in air of normal density."

Whenever radiant energy falls on an absorbent surface in air, such as a disc of blackened wood, its wave-length is degraded or lowered, and it is converted into thermometric heat. The molecules of air striking this warmed surface acquire heat, and move away from it with increased velocity, and as action and reaction are always alike in moving away, they give the body a "kick." Since there is no such action on the other side of the disc, there is a difference of pressure between the two sides, which gives it a tendency to move away from the source of energy. The effect is very much smaller in air at ordinary pressures than in air at a very low vacuum, because in the former case, the mean free path of the molecules is very small, and the rebounding molecules help to keep back the more slowly approaching molecules. Nevertheless, molecular pressure is experienced, and if of sufficient magnitude and rapidity it ought to produce sonorous vibrations. It seemed probable that the element of time does not enter here so prominently as in the previous case, for the radiometer effect is a mere surface action of the disc, and not one effecting its mass. Hence it was hoped that the retarding effects would be eliminated. If the sonorous action, therefore, be due to a radiometer action, a difference of effect would be observed if the side of a disc *exposed* to the source of energy, be either blackened by lamp-black or camphor carbon, or if it be polished or whitened.

* This conclusion was confirmed by subsequent experiments, notably by Experiments 7 and 41.

An apparatus (fig. 2) was constructed similar in principle to that described by Messrs. Bell and Tainter. The source of light, L, was an oxy-hydrogen lime-light.

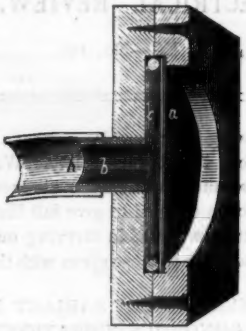


FIG. 3.

The rotating disc, R, was of zinc perforated with holes, which could be noiselessly rotated, so as to obtain 1,000 intermissions per second. A glass lense G, was employed to focus the light upon the perforations of the rotating disc, and another, G', to render the rays parallel on the other side of the disc. A mahogany case or cup, C, to retain the discs to be experimented upon was constructed as shown in section in fig. 3, and fixed 400 centims. from the source, L; *a*, being the disc 5 centims. in diameter, clamped on by screws; *b*, a brass tube, to which the india-rubber hearing tube, *h*, was fixed; *c*, a circular air space behind the disc, 6 centims. in diameter, and 3 millims. to 5 millims. deep. Cavities of various dimensions and forms, spherical, conical, and trumpet-shaped, were tried, but the ones described were those which gave the best effects.

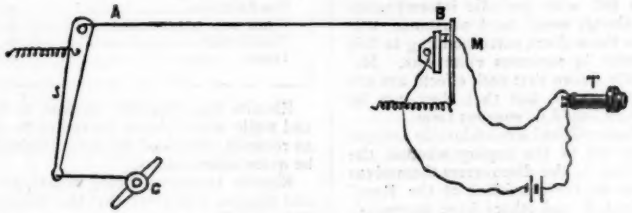


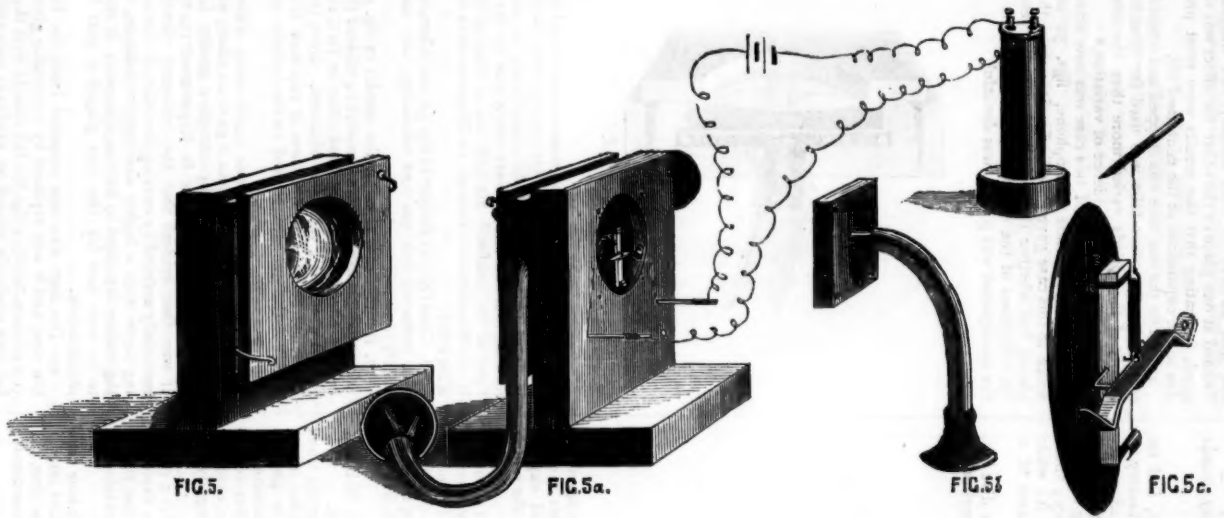
FIG. 1.

Experiment 2.—An ebonite disc well blackened on one side when exposed to the intermittent rays was found to produce sounds, which Professor Hughes estimated to be about 20 as compared by his sonometer scale.*

3.† A similar ebonite disc equally well whitened, gave slightly less intense sounds, estimated at 18.

* Professor Hughes' sonometer (*Proc. Roy. Soc.*, vol. xxix., p. 56) proves an excellent apparatus to estimate the relative intensity of low sounds, for by shifting the induction coil from one side to the other, we can pass from an absolute zero, or pure silence, to a limit of sound of considerable intensity. The scale divides this space passed over into 100 equal parts, any number of which give a fairly approximate value of the sounds compared. The ear has to determine the equality of the intensity of the two sounds, *i. e.*, of the sonometer and the source investigated, and the value of the latter is given in terms of the scale of the former.

† The consecutive figures indicate the number of the experiments.



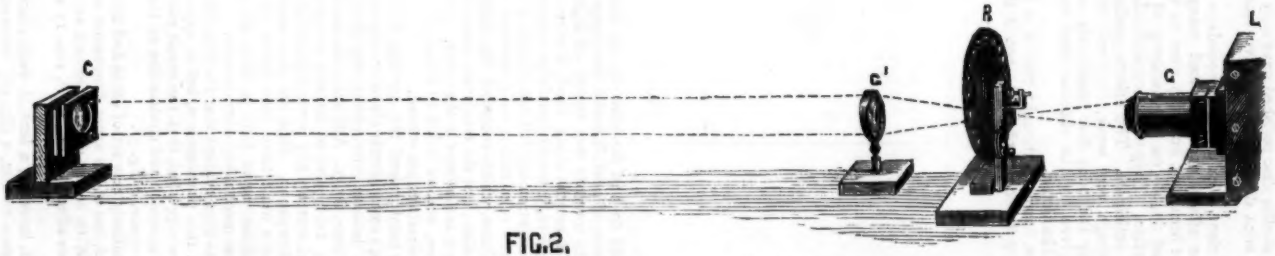


FIG.2.

FIG. 5.—Front of receiver with lens inserted. FIG. 5*a*.—Rear of receiver with back piece, FIG. 5*b*, removed to exhibit microphone attached to disc. See also FIG. 5*c* for enlarged drawing of microphone attached to disc.

4. A zinc disc blackened gave sounds = 8.

5. A similar disc polished gave only sounds = 2.

6. A mica disc blackened gave scarcely any sounds at all.

7. A clean mica disc gave sounds = 5.

These effects were produced many times, and on different occasions, and they were so unsatisfactory as to throw doubts on the accuracy of the radiometer explanation. They were not so decided as theory led one to anticipate. The effects produced by the zinc disc, though very weak, favoured the theory; those given by the mica disc completely refuted it; while those given by the ebonite discs were almost of a neutral character.

It was, however, thought that if D be the disc (fig. 4), and C the source of light, then if the excursions of

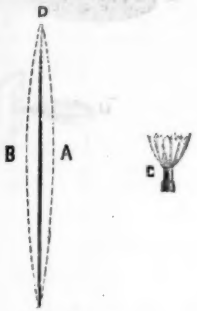


FIG. 4.

the discs to and fro were due to expansion from the absorption of heat, it would first bulge towards A, since the side towards the source of light would expand first. If, on the other hand, it were due to the radiometer effect, it would first bulge towards B.

8. An extremely delicate electrical contact arrangement was constructed to determine this by means of a telephone, which recorded the excursions to and fro of the disc; but the result was sometimes in one direction and sometimes in the other. Moreover, the effect was slow, and we failed to obtain more that five distinct vibrations per second.

This result raised the question whether in Bell and Tainter's experiments *the discs vibrated at all.*

9. A delicate microphone was fixed in various ways on the case, fig. 3. Although the sounds emitted in the hearing tube were as intense as indicated in Experiment 1, scarcely any perceptible effect was detected on the microphone. Had the disc sensibly vibrated, its vibrations must have been taken up by the case. A microphone never fails to take up and magnify the minutest mechanical disturbances.

It was thus evident that the disc did not play a prime part in this phenomenon, but it appeared as Professor Hughes suggested, that the result might be due wholly to an expansion and contraction of the air contained in the air space, *c* (fig. 3).

An entirely new set of cases and discs were now constructed, but of the same dimensions as the first set.

10. With a new clean case and an ebonite disc, the sonorous effects were feeble, viz., 15 on the sonometer scale.

11. If, however, a lens, *d*, were placed close in front of the ebonite disc, *a* (fig. 5*d*), the sonorous effects were magnified considerably, rising at once to about 40.

12. A case was constructed similar to that shown in fig. 5*d*, but with a tube at the side, as well as one at the back, communicating with the air cavity in front of the disc as well as that behind, and whether one listened at one place or the other the effect was equally good, indicating that the results were most probably due to the expansions of the contained air.

13. When the one tube was stopped and opened by a cork while the other tube was used for listening, the quality of the sounds varied more than the intensity, but there was distinct evidence of variation.

14. The ebonite disc of this case was now fitted with an extremely delicate microphone, figs. 5*a* and 5*c*, which in this case gave good indications upon the telephone, but whether the vibrations were the results of the vibrations of the disc itself, or of the air in which the microphone was placed, was doubtful.

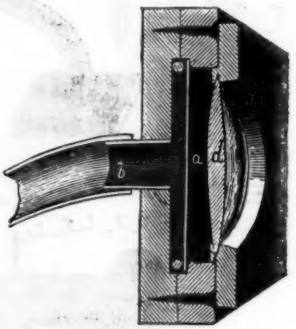


FIG. 5*d*.

15. If the lens, *d* (fig. 5*d*), were removed, and the disc left supported without any air cavity, either behind or in front of it, *no perceptible sound could be obtained*, proving that the effects were really due to the vibrations of the confined air, and *not to those of the disc.* It was therefore determined to dispense with the disc altogether.

16. Case (No. 1) similar to fig. 5*d* was taken, and the disc removed, but the lens remaining, the sonorous effects were *nil.*

17. Another case (No. 2), also similar to fig. 5*d*, was taken under similar circumstances, *i.e.*, *without the disc*, but the effects were very loud—60; in fact, the best results which had yet been obtained. Now, the only difference between the one case or cup and the other was that the one *was blacked in the interior* and the other was not.

18. Hence case No. 1 was again taken without the disc, and though when clean it gave no effect, when its interior was blacked by camphor smoke it gave sounds as strong as those in Experiment 17, viz., 60. It was thus evident that the sonorous effects were materially assisted by coating the sides of the containing vessel with a highly absorbent substance, such as the carbon deposited by burning camphor. It remained to be seen how far the lens played a part in this phenomenon.

19. The lens was now removed from the front of the case, and it was replaced by a movable glass plate (1·5 millims. thick), *e* (fig. 6); the sounds were the same, but they gradually ceased on gradually uncovering the front opening of the case, so as to give the air room to expand.

20. The glass plate, *e*, was replaced by a heavy rigid plate of rock salt, 13 millims. thick, and the sounds were equally loud, namely, = 60.

21. The plate, *e*, was replaced by white note paper. The sounds were very faint but perceptible.

22. It was replaced by thin cardboard, and the effect was *nil.*

23. All these effects were produced equally well, whether the cases were placed at C (fig. 2), 400 centims. from the source of light, or 16 centims. from the rotating disc, R, but in the latter case their intensity was of course always increased.

Hence it is abundantly evident that these sonorous vibrations are due to the motions of the contained air, and not to those of the disc; that they are actually improved by the removal of the disc, that their production is materially assisted by lining the surface of

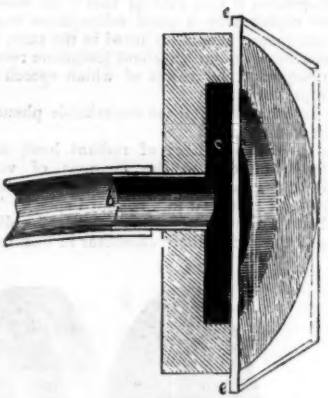


FIG. 6.

the containing space with an absorbent substance, that they are dependent on the heat rays that pass through, and that they disappear when the rays are cut off from the air cavity by an athermanous diaphragm.

24. Dr. Tyndall having shown in the paper already referred to, that water vapour responded actively to these intermittent actions, a clean empty one-ounce glass flask was taken and exposed to the intermittent beams. No sound was produced.

25. It was then filled with water vapour by pouring a small quantity of water into it, and warming it in a flame; fair sounds of an intensity 25 were the result.

26. The flask was filled with the dense smoke from burning camphor, and the sounds were intensified considerably.

27. The case (fig. 6) was taken and a glass plate 1·5 millims. thick fixed in front of it as before.

a. When the glass was dry, sounds were 20.

b. When the glass was wetted on the inside, sounds were 25.

28. Another clear one-ounce glass flask was taken.

a. When clear, sounds = 0.

b. When filled with tobacco smoke, sounds = 5.

c. When filled with heavy camphor smoke, sounds = 30.

29. One side of the flask was blackened on the outside, the other side remaining clear.

a. On exposing the clear side to the light, fair sounds, 25, were obtained.

b. On exposing the blackened side, *no sounds were produced.*

30. The flask was blackened *in the interior* on one side only.

a. When the blackened side was near the source, sounds = 25.

b. When it was away from the source, sounds = 30.

c. When the flask was cleaned, all sounds disappeared.

31. A thin glass plate was now blackened on one side and placed in front of the case, fig. 6.

a. When the black surface was outside, *no sounds were obtained.*

b. When the black surface was inside, good sounds, 30, were the result.

c. When the glass was cleaned, the sounds became = 50.

32. An ebonite plate was similarly treated.

a. When the blackened surface was outside, sounds = 15 were obtained.

b. When the blackened surface was inside, the sounds were = 3.

This being an anomalous result, several experiments were now made to test the behaviour of opaque and transparent bodies, when used as discs, for while in the previous experiments the effect was greatest when the blackened surface faced the interior, here we find the opposite result produced, viz., the greatest effect was produced when the blackened surface was on the exterior.

33. Another ebonite disc 0·6 millim. thick was made dull on both sides by rubbing it with emery paper. It was fixed in case (No. 2), fig. 5*d*, without the lens.

a. It gave sounds = 15.

b. It was now blacked on one side, and when that side was turned to the source, it gave sounds = 30.

c. The unblackened side was turned to the source, and it gave sounds = 15.

34. A thin glass plate (1·5 millims. thick)—

a. When clear, gave sounds = 50.

b. When blackened *thinly* on one side, and that side turned to the source, it gave sounds = 20.

c. When blackened thickly on one side and thinly on the other—

1. Thick side to light, sounds = 0.
2. Thin side to light, sounds = 20.

35. A glass plate (3 millims. thick) was blackened on one side.

a. Black outside, sounds = 2.

b. „ inside „ = 30.

36. A clean mica plate (1·2 millims. thick)—

a. Gave sounds = 30.

b. When blacked on one side.

1. Black outside, sounds = 10.
2. „ inside „ = 30.

37. Thin copper foil blacked on either side, sounds were *nil.*

38. A copper disc (0·2 millim. thick) blackened on one side.

a. Black outside, sounds = 3.

b. „ inside „ = 0.

39. Zinc foil blacked on one side.

a. Black outside, sounds = 10.

b. „ inside „ = 3.

40. Zinc disc (0·7 millim. thick) blackened on one side.

a. Black outside, sounds = 10.

b. „ inside „ = 3.

It thus appears that transparent bodies behave in an opposite way to opaque bodies. Glass and mica can be rendered athermanous and silent by making the carbon deposit sufficiently thick. Zinc, copper, and ebonite can produce sonorcus effects by a proper dis-

position of carbon. The effect in these latter cases may be due either to molecular pressure, in fact, to a radiometer effect, though very feeble in intensity; or it may be the result of conduction through the mass of the diaphragm, that is, radiant heat is reduced to thermometric heat by absorption by the carbon deposit on the *outside* of the disc, this heat is transmitted through the disc and radiated to the absorbent gases in the interior.

41. To test these questions, a delicate microphone was fixed on a zinc disc (0·7 millim. thick) without any air cavity in front of or behind it.

a. The disc was blackened; no measurable trace of sound was perceptible.

b. The disc was cleaned, with precisely the same result.

42. The zinc disc was now replaced on the case, fig. 5*d*, with the air cavity, and sounds = 10 were emitted as before.

a. The zinc was neatly covered with white paper —a highly athermanous substance; the sounds were *nil*.

b. The paper was blackened; the sounds were still *nil*.

c. The zinc was covered with clear mica; faint but unmeasurable sounds were heard.

d. The mica was blackened; no perceptible sounds were obtained.

e. The zinc disc was blackened slightly in the usual way; sounds = 10 were obtained.

f. The zinc was *thickly* blackened; all sounds disappeared.

43. Ebonite discs of different thicknesses were used, and layers of carbon of different thicknesses were deposited on the thinnest of them. The sounds became fainter and fainter as the thickness of the layer of carbon and the thickness of the ebonite increased, until they disappeared altogether.

These experiments fully establish the inference that the effect is one of conduction, and that the blackened surface of an opaque body like zinc acts as though the source of heat were transferred to the outside surface of the disc.

44. Tubes of various sizes and dimensions were now tried, to confirm Messrs. Bell and Tainter's observations on tubes. They invariably gave out satisfactory sounds when the intermittent rays were directed into the interior of the tubes, which were always considerably intensified by blackening their interiors, and closing the open end with a glass plate.

45. Since the sounds varied considerably in intensity, according to the number of intermittences per second transmitted, white and ruby glass plates were used, and it was found that the maximum effect (60) was produced when the note corresponding to the intermittences was—

With white glass..... $a' = 297$ vibrations per sec.
With ruby „ ..... $b = 247$ „ „

This showed that the element of time was a function of the amount of radiant energy transmitted through the plate.

46. The two cases, which possessed air cavities of different dimensions, were tried with white glass:

Case 1 gave $b = 247$ vibrations per second.
Case 2 „ $a' = 297$ „ „

Hence it is evident that there is a time element, and that the loudness of the note emitted depends upon the rapidity with which the contained air not only absorbs the degraded energy, but upon the rapidity with which it gives up its heat to the sides of the case and the exits open to it. Though the pitch of the maximum note varied with the cavity and the amount of radiant heat transmitted, its quality never varied, notwithstanding the great diversity of materials used as diaphragms.

47. Since these sonorous effects are due to the expansions of absorbent gases under the influence of heat, and since wires are heated by the transference of electric currents through them, it seemed possible that if we inclosed a spiral of fine platinum wire, P (fig. 7), in a dark cavity, *a*, *b*, *c*, *d*, well blacked on the inside, and sent through it, by means of the wheel-break, W, rapid intermittent currents of electricity from the battery, B, heat would be radiated, the air would expand, and sounds would result. This was done, and the sounds produced were excellent. In fact, with four bichromate cells, sounds more intense than any previously observed were obtained.

Furthermore, it was evident that if the wheel-break, W, were replaced by a good microphone transmitter, articulate speech should be heard in the case, *a*, *b*, *c*, *d*. This was done, and an excellent telephone receiver was the consequence, by means of which speech was perfectly reproduced.

The explanation of these remarkable phenomena is now abundantly clear.

It is purely an effect of radiant heat, and it is essentially one due to the changes of volume in vapours and gases produced by the degradation and absorption of this heat in a confined space. The discs in Bell and Tainter's experiments must be diathermanous, and the better their character in this respect the

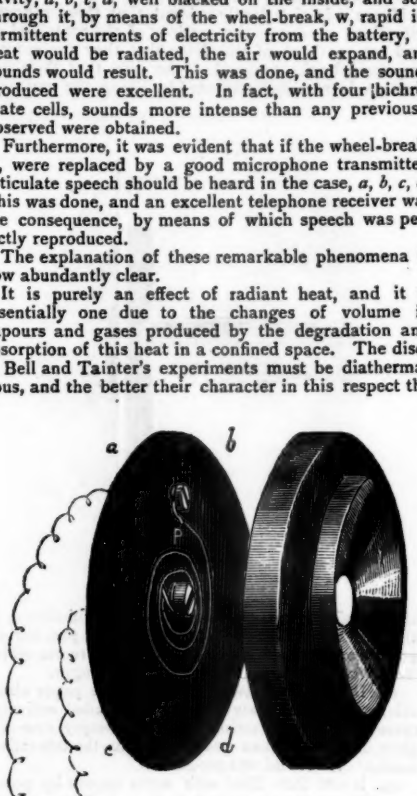


FIG. 7.

greater the effect; remove them, and the effect is greater still. Messrs. Bell and Tainter* showed that the sounds maintained their *timbre* and pitch notwithstanding variation in the substance of the disc, and M.

* *Journal of Society of Telegraph Engineers*, December 8, 1880.

Mercadier found that a split or cracked plate acted as well as when it was whole. These facts are consistent with the expansion of the contained air, but not with any mechanical disturbance of the discs. Moreover, M. Mercadier showed that the effect was improved by lamp-black, but he applied it in the wrong place.

The discs may, and perhaps do under certain conditions, vibrate, but this vibration is feeble and quite a secondary action. The sides of the containing vessel must possess the power to reduce the incident rays to thermometric heat, and impart it to the vapour they confine, and the more their power in this respect, as when blackened by carbon, the greater the effect. The back of the disc may alone act in this respect. Cigars, chips of wood, smoke, or any absorbent surfaces placed inside a closed transparent vessel will, by first absorbing and then radiating heat rays to the confined gas, emit sonorous vibrations.

The heat is dissipated in the energy of sonorous vibrations. In all cases, time enters as an element, and the maximum effect depends on the diathermancy of the exposed side of the cavity, on its dimensions and surfaces, and on the absorbent character of the contained gas.

The remarkable property which deposited carbon possesses of reducing radiant energy to thermometric heat is strikingly shown by these experiments, and it suggests an important field for inquiry for those who are working in the region of radiant heat.

It is only necessary to add that, in carrying out these experiments, I have had the benefit of the presence and advice of Professor Hughes, and the inestimable advantage of the great mechanical skill, philosophical character, and experimental ability of Mr. Stroh, without whom, in fact, the inquiry could not have been accomplished.

ADDITIONAL NOTE. Received March 14, 1881.

Professor Stokes has suggested that the action is due, not to the expansion of the contained vapour through its absorption of thermometric heat generated on the lamp-black surface, but to the *contact* of the air molecules with this surface. It is clear that when the carbon is warmed, the rapidly moving air molecules which strike it and bound off have their retreating motion increased in velocity. This increased velocity means increased pressure, which in its turn produces increased volume, and this, when intermittent, produces sonorous vibrations. This explanation is quite in accordance with the observed facts, for the difference of the intensity of the sounds emitted by dry air and air charged with absorbent vapours is very much less when a lamp-black surface is used than was anticipated. Dry air gives excellent results with lamp-black, but is silent without it. Indeed it leads one to conceive that as charging the air with heavy smoke produces the same effect as coating the containing surface with lamp-black, each particle of smoke becomes a warmed surface from which the colliding air molecules, whose dimensions are infinitely smaller, retreat with increased velocity. Moreover, if we conceive the smoke particles replaced by the compound molecules of absorbent vapours, such as sulphuric ether, olefiant gas, or ammonia, and if we assume the dimensions of these molecules greater than those of the air, we have an explanation not only of the absorbent power of these gases, but of the reasons for their behaviour in converting radiant energy into sonorous vibrations. It is clear that if the compound molecule act as a smoke particle, the radiant energy becomes degraded into thermometric heat, for the motion of the ether is transferred to the motion of the molecule. The minute air molecules move unaffected in the undulating ether, but the larger compound molecules of the absorbent gas take up the waves of the ether, and assume that form of motion which is known as thermometric heat. Hence, the greater the number of molecules and the larger their dimensions, the greater the absorption of heat and the more the production of sonorous vibrations, for a greater number of air atoms will collide with warmed surfaces in a given time. That this assumption is justified is proved by the fact that this absorption of radiant energy renders the particles of dissociated nitrite of amyl and other vapours visible as well as warm, and therefore they can assume dimensions that are comparable with the particles of smoke.

MOLECULAR ELECTRO-MAGNETIC INDUCTION.

By Professor D. E. HUGHES, F.R.S.
(Read before the Royal Society, March 17th, 1881.)

THE induction currents balance which I had the honour of bringing before the notice of the Royal Society * showed how extremely sensitive it was to the slightest molecular change in the composition of any metal or alloy, and it gave strong evidence of a peculiarity in iron and steel which its magnetic properties alone failed to account for. We could with all non-magnetic metals easily obtain a perfect balance of force by an equivalent piece of the same metal, but in the case of iron, steel, and nickel it was with extreme difficulty that I could obtain a near approach to a perfect zero. Two pieces of iron cut off the same bar or wire, possessing the same magnetic moment, never gave identical results; the difficulty consisted, that notwithstanding each bar or wire could be easily made to produce the same inductive reaction, the time during which this reaction took place varied in each bar; and although I could easily change its balancing power as regards inductive force by a change in the mass of the metal, by heat or magnetism, the zero obtained was never equal to that obtained from copper or silver.

This led me to suppose the existence of a peculiarity in magnetic metals which could not be accounted for except upon the hypothesis that there was a cause, then unknown, to produce the invariable effect.

Finding that it would be impossible to arrive at the true cause without some new method of investigation, which should allow me to observe the effects from an electrical circuit, whose active portion should be the iron wire itself, I constructed an apparatus or electro-magnetic induction balance, consisting of a single coil reacting upon an iron wire in its axis, and perpendicular to the coil itself; by this means the iron or other wire itself became a primary or secondary, according as the current passed through the coil or wire. Now, with this apparatus we could induce secondary currents upon the wire or coil, if the coil was at any angle, except when the wire was absolutely perpendicular; in this state we could only obtain a current from some disturbing cause, and the current so obtained was no longer secondary but tertiary.

The whole apparatus, however, is more complicated than the general idea given above, as it was requisite not only to produce effects but to be able to appreciate the direction of the electrical current obtained, and

* *Proc. Roy. Soc.*, vol. xxix., p. 56.

have comparative measures of their value. In order to fully understand the mode of experiments, as well as the results obtained, I will first describe the apparatus employed.

The electro-magnetic induction balance consists—1st, of an instrument for producing the new induction current; 2nd, sonometer or balancing coils; 3rd, rheotome and battery; 4th, telephone.

The essential portion of this new balance (Fig. 1) is that wherein a coil is so arranged that a wire of iron or copper can pass freely through and forming its axis. The iron or copper wire rests upon two supports 20 centims. apart; at one of these the wire is firmly clamped by two binding screws; the opposite end of the wire turns freely on its support, the wire being 22 centims. long, having 2 centims. projection beyond its support, in order to fasten upon it a key or arm which shall serve as a pointer upon a circle giving the degrees of torsion which the wire receives from turning this pointer. A binding screw allows us to fasten the pointer at any degree, and thus preserve the required stress the time required.

The exterior diameter of the coil is 5½ centims., having an interior vacant circular space of 3½ centims., its width is 2 centims.; upon this is wound 200 metres

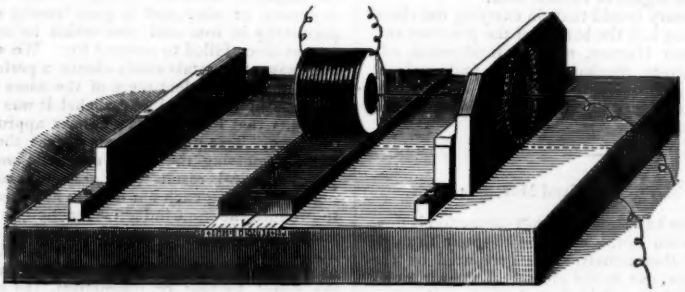


FIG. 1.—INDUCTION BALANCE.

of No. 32 silk-covered copper wire. This coil is fastened to a small board so arranged that it can be turned through any desired angle in relation to the iron wire which passes through its centre, and it can also be moved to any portion of the 20 centims. of wire, in order that different portions of the same wire may be tested for a similar stress.

The whole of this instrument, as far as possible, should be constructed of wood, in order to avoid, as far as possible, all disturbing inductive influences of the coil upon them.

The iron wire at its fixed end is joined or makes contact with a copper wire, which returns to the front part of the dial under its board and parallel to its coil, thus forming a loop, the free end of the iron wire is joined to one pole of the battery, the copper wire under the board is joined to the rheotome and thence to the battery.

The coil is joined to the telephone but, as in every instance we can either pass the battery through the wire, listening to its inductive effects upon the wire, or the reverse of this, I prefer, generally, in order to have no voltaic current passing through the wire, to join the iron wire and its loop direct to the telephone, passing the voltaic current through the coil.

In order to balance, measure, and know the direction of the new induction currents by means of a switching key, the sonometer* I described to the Royal Society is brought into the circuit. The two exterior coils of the sonometer are then in the circuit of the battery, and of the coil upon the board containing the iron wire or stress bridge. The interior or movable coil of the sonometer is then in the circuit of the iron wire and telephone. Instead of the sonometer constructed as described in my paper to the Royal Society, I prefer to use one formed upon a principle I described in *Comptes Rendus*, December 30, 1878. This consists of two coils only (Fig. 2), one of which is smaller and turns freely in the centre of the outside coil. The exterior coil being stationary, the centre coil turns upon an axle by means of a long (20 centims.) arm or pointer, the point of which moves over a graduated arc or circle. Whenever the axis of the interior coil is perpendicular to the exterior coil, no induction takes place, and we have a perfect zero: by turning the interior coil through any degree we have a current proportional to this angle, and in the direction in which it is turned. As this instrument obeys all the well-known laws for galvanometers, the readings and evaluations are easy and rapid.

If the coil upon the stress bridge is perpendicular to the iron wire, and if the sonometer coil is at zero, no currents or sounds in the telephone will be perceived, but the slightest current in the iron wire produced by torsion will at once be heard; and by moving the sonometer coil in a direction corresponding to the current, a new zero will be obtained, which will not only balance the force of the new current but indicate its value. A perfect zero, however, will not be obtained with the powerful currents obtained by the torsion of 2 millims. diameter iron wire, we then require special arrangements of the sonometer which are too complicated to describe here.

The rheotome is a clockwork, having a rapid revolving wheel which gives interruptions of currents in fixed cadences in order to have equal intervals of sound and silence. I employ four bichromate cells or eight Daniell's elements, and they are joined through this rheotome to the coil on the stress bridge, as I have already described.

The magnetic properties of iron, steel, nickel, and cobalt, have been so searchingly investigated by ancient as well as by modern scientific authors, that there seems little left to be known as regards its molar magnetism. I use the word molar here simply to distinguish or separate the idea of a magnetic bar of iron or steel magnetised longitudinally or transversely from

* *Proc. Roy. Soc.*, vol. xxix., p. 65.

the polarised molecules which are supposed to produce its external magnetic effects.

Molar magnetism, whilst having the power of inducing an electric current in an adjacent wire, provided that either has motion or a change in its magnetic force, as shown by Faraday in 1832, it has no power of inducing an electric current upon itself or its own molar constituent, either by motion or change of its magnetic moment. Molecular magnetism (the results of which, I believe, I have been the first to obtain) has no, or a very feeble, power of inducing either magnetism or an electric current in an adjacent wire, but it possesses the remarkable power of strongly reacting upon its own molar wire, inducing (comparatively with its length) powerful electric currents, in a circuit of which this forms a part.

In some cases, as will be shown, we may have both cases existing in the same wire; this occurs when the wire is under the influence of stress, either external or internal; it would have been most difficult to separate these two, as it was in my experiments with the induction balance without the aid of my new method.

Ampère's theory supposes a molecular magnetism or polarity, and that molar magnetism would be produced when the molecular magnetism became symmetrical; and his theory, I believe, is fully capable of explaining the effects I have obtained, if we admit that we can rotate the paths of the polarised molecules by an elastic torsion.

Matteucci made use of an inducing and secondary coil in the year 1847,* by means of which he observed that mechanical strains increased or depressed the magnetism of a bar inside this coil.

Wertheim published in the *Comptes Rendus*, 1852,† some results similar to Matteucci; but in the *Annales de Chimie et de Physique*, 1857,‡ he published a long series of most remarkable experiments, in which he clearly proves the influence of torsion upon the increment or decrement of a magnetical wire.

Vilari showed§ increase or diminution of magnetism by longitudinal pull according as the magnetising force is less or greater than a certain critical value.

Wiedermann,‖ in his remarkable work *Galvanismus*, says that an iron wire through which an electric current is flowing becomes magnetised by twisting the wire. This effect I have repeated, but found the effects very weak, no doubt due to the weak battery I use, viz., four quart bichromate cells.

Sir W. Thomson shows clearly in his remarkable contribution to the *Phil. Trans. Roy. Soc.*, entitled "Effects of Stress on the Magnetisation of Iron, Nickel, and Cobalt,"* the critical value of the magnetisation of these metals under varying stress, and also explains the longitudinal magnetism produced by Wiedermann as due to the outside molar twist of the wire, making the current pass as in a spiral round a fixed centre. Sir William Thomson also shows clearly the effects of longitudinal as well as transversal strains, both as regards its molar magnetism and its electric conductivity.

My own researches convince me that we have in molecular magnetism a distinct and separate form of magnetism from that when we develop, or render evident, longitudinal, or transversal magnetism, which I have before defined as molar.

Molecular magnetism is developed by any slight strain or twist other than longitudinal, and it is only developed by an elastic twist; for, however much we may twist a wire, provided that its fibres are not separated, we shall only have the result due to the reaction of its remaining elasticity.

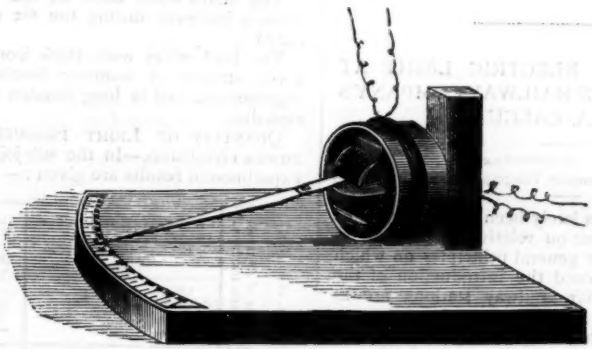


FIG. 2.—SONOMETER.—For first arrangement of Sonometer *see* TELEGRAPHIC JOURNAL, p. 180, vol. vii.

If we place an iron wire, say 20 centims. long, 1 millim. diameter, in the axis of the coil of the electromagnetic balance, and if this wire is joined, as described, to the telephone, we find that on passing an electric current through the inducing coil no current is perceptible upon the iron wire; but if we give a very slight twist to this wire at its free end—one-eighteenth of a turn, or 20°—we at once hear, clear and comparatively loud, the currents passing the coil; and although we only gave a slight elastic twist of 20° of a whole turn, and this spread over 20 centims. in length, making an extremely light molar spiral, yet the effects are more powerful than if, using a wire free from stress, we turned the whole coil 40°. The current obtained when we turn the coil, as just mentioned, is secondary, and with the coil at any angle any current produced by its action, either on a copper, silver, iron, or steel wire; in fact, it is simply Faraday's discovery, but the current from an elastic twist is no longer secondary under the same conditions, but tertiary, as I shall demonstrate later on. The current passing through the coil cannot induce a current upon a wire perpendicular to itself,

* *Compt. Rend.*, t. xxiv., p. 301, 1847.
† *Compt. Rend.*, t. xxv., p. 702, 1852.
‡ *Ann. de Chim. et de Phys.* (3), t. l., p. 385, 1857
§ Poggendorff's *Annalen*, 1868.
‖ Wiedermann's *Galvanismus*, p. 447.

* *Phil. Trans*, May 6, 1878.

but the molecules of the outside of the wire, being under a greater elastic stress than the wire itself, they are no longer perpendicular to the centre of the wire, and consequently they react upon this wire as separate magnets would upon an adjacent wire. It might here be readily supposed that a wire having several twists, or a fixed molar twist of a given amount, would produce similar effects. It, however, does not, for in most cases the current obtained from the molar twists are in a contrary direction to that of the elastic torsion. Thus, if I place an iron wire under a right-handed elastic twist of 20°, I find a positive current of 50° sonometer; but if I continue this twist so that the index makes one or several entire revolutions, thus giving a permanent molar twist of several turns, I find upon leaving the index free from any elastic torsion, that I have a permanent current of 10°, but it is no longer positive, but negative, requiring that we should give an elastic torsion in the previous direction, in order to produce a positive current. Here a permanent elastic torsion of the molecules is set up in the contrary direction to its molar twist, and we have a negative current, overpowering any positive current which should have been due to the twisted wire.

(*To be continued.*)

REPORT ON THE ELECTRIC LIGHT AT THE EAST INDIAN RAILWAY COMPANY'S STATION, HOWRA, CALCUTTA.

By LOUIS SCHWENDLER,
Electrician of Government Telegraphs in India.

THIS report, which has lately been printed, contains much valuable information relative to the cost of electric lighting. The general principles on which Mr. Schwendler proposed the introduction of the electric light in Indian railway stations are as follows:—

"The station is to be lighted up by a certain number of powerful electric lights; each electric light being produced by *one* dynamo-electric machine and *one* electric lamp; the leading wires to be so thick that the least possible useless heat will be developed in them, and consequently the greatest possible useful heat in the lamps, in order to obtain the maximum light with the minimum power. By an opaque reflector each light is projected against the white ceiling from which it is diffused over a considerable area of the space to be lighted up; as far as practically possible no *direct* rays are allowed to enter the retina."

This method the author considered his experiments in London in 1877-78 clearly showed to give the best and most economical results, and later experiments, both in England and other countries, have verified this conclusion. The engine employed to drive the dynamo machines was a two-piston horizontal one of 25 horse-power, and worked at 50 to 65 revolutions per minute, with a steam pressure of 40 lbs.; native coal at rather less than 6 rupees (12 shillings) per ton was employed as fuel.

Since the regularity of any electric light depends in the first place upon the constancy of speed of the dynamo-electric machines, it is of paramount importance to be able to see at a glance the speed of the engine. By the aid of a Napier mercurial speed indicator it was possible to detect any variation of the speed *at once*, and to keep the engine at a constant speed within 2 per cent.

The shafting of the dynamo-electric machines was driven from the engine by means of six 5-inch Manilla ropes; these latter were used instead of belting to avoid slipping, and answered the purpose well.

The following were the speeds for the five dynamo-electric machines in use :—

Dynamo-electric machine.	No. of revolutions per minute of induction cylinder.	Speed of shafting.	Mercury speed indicator.	Speed of engine.
A ...	805	186	64	62
B ...	1,097			
C ...	870			
D ...	1,042			
E ...	643			

The lamps when once set did not require any fresh adjustment during the six months the trial lasted.

The lead wires were thick iron ropes made of seven strands of ordinary fencing wire twisted together and laid in long wooden boxes filled with asphalte.

QUANTITY OF LIGHT PRODUCED AND HORSE-POWER CONSUMED.—In the sub-joined table all the experimental results are given :—

No. of circuit.	Name of dynamo-electric machine.*	Resistance in circuit at 80° F. not including resistance of arc. Ohms.			Length of leading wires in feet. (Iron rope) only.	Electric light diffused by reflector in standard candles.	H. P. required to drive each dynamo-electric machine.
		Of dynamo-electric machine.	Of leading wires.	Total.			
I.	A	0·584	·228	·812	238 × 2	3225	4·8
II.	B	0·805	·247	1·052	358 × 2	2047	3·0
III.	C	1·190	·280	1·470	475 × 2	1500	2·4
IV.	D	1·423	·458	1·881	595 × 2	1450	2·5
I.	E	0·622	·300	·922	238 × 2	4000	4·6

Of these machines, A was spare and B, C, D and E were used for lighting. Hence the light of 8,997 standard candles is given for a consumption of 12·5 horse-power, or total light of four lamps equals 9,000 candles, or 720 candles per horse-power, giving 19 standard candles per 100 square feet area. That this was a sufficient light was tested by bringing the light of an oil lamp or gas jet into the shed. Any such light looked red compared with the diffused electric light.

As regards the cost of the light compared with gas, Mr. Schwendler gives all the items of expenditure, but as these are entirely based upon the cost of labour and material in India they are of but little if any value in determining what the same relative

* A, B, and E are Siemens dynamo-electric machines; A is the medium and B the small-sized machine; E is of the same size as A, only altered according to my specification. C and D are Gramme dynamo-electric machines.

cost would be in England. Under the best conditions, when the light is burning continuously, the cost is shown to be as about 9 to 1 in favour of the electric light; under the most unfavourable conditions, that is, when the light is but little used, and when the cost for labour in attending to the machinery remains still the same, then the economy is as 1 to from 1·5 to 3·7 in favour of the electric light.

The cost of gas is taken as 10s. per 1,000 c. feet. In England the cost of gas is of course much less, and the cost of labour for attending to the machinery is greater, thus the labour in India is estimated as follows:—

Kind of labour.	Salary per month.	Half the salary per day is charged to the electric light when burning.
Engine driver ...	29 Rs. ...	0·483
Oiler	16 „ ...	0·267
Fireman	9 „ ...	0·150
Cooly	9 „ ...	0·150
Durwan	7 „ ...	0·117
	Rs. Total	1·167

The cost of coal is rather less than 6 Rs. per ton, or 1·159 Rs. per hour; carbon electrodes for 4 lamps, ·503 Rs. per hour.

That the electric light is better adapted for a hot country like India than ordinary combustion light is clear from the fact, established by the author's London experiments, that the electric light produces at least *fifty times less* heat than if the same light is produced by the combustion method (gas, oil, or candle light).

TELEGRAPHIC APPARATUS IN USE IN THE BRITISH POSTAL TELEGRAPH DEPARTMENT.

XXX.

THE WHEATSTONE AUTOMATIC SYSTEM.

(*Continued.*)

THE FAST DUPLEX REPEATER.

THE most complicated arrangement of apparatus employed in connection with the Wheatstone Automatic System is, perhaps, the "Fast Speed Duplex Repeater;" this combination is shown by fig. 123.

The complete set comprises:—One Wheatstone receiver; three standard relays; two sounders; two keys; two rheostats with condensers; one "leak" rheostat; two galvanometers; two rheostats; two plug switches; one bar switch; in addition, of course, to the batteries.

When the plugs are inserted in switches, S^w1 and S^w2, and the bars of the bar switch, F, are in the position shown in the figure, the apparatus is arranged for working as a duplex repeater, and in order to understand its action we must consider what is necessary in order that duplex repetition may be carried on.

Supposing that we have two relays, A and B, at the repeating station, A being connected to the "Down" line and B to the "Up" line. Now, if we suppose the tongue and contacts of relay, B, to be simply a double current key, and if we also suppose its local connections to be joined up to relay, B, and to the "Down" line, as in an ordinary double current duplex (Article XI., June 15th, 1880), then it is obvious that all the signals sent from the distant station on the Down line will be properly received on relay, A, whilst the signals sent by the tongue of relay, B, will also be properly received at the station on the Down line. It is the same thing whether the tongue of relay, B, sends out reversals, like an ordinary double current key, or whether it sends them out by means of a split battery earthed in the middle.

If we connect the line connections of relay, B, to the "Up" line, then the signals received from the "Up" line will obviously be repeated, by means of the tongue of relay, B, as before explained, on to the "Down" line; and, again, if the tongue of relay, A, be connected to the relay, B, and the "Up" line in the ordinary double current duplex manner, then it is obvious that the signals received on A from the "Down" line will be repeated on to the "Up" line. Thus the signals from either line will be repeated without confusion.

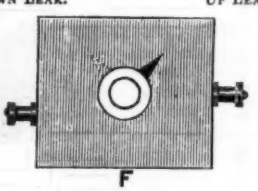


FIG. 124.

The general arrangement of the relays, galvanometers, and rheostats, may be seen from fig. 122. The keys, N_1, N_2 (fig. 123), which are similar to those employed in the fast repeater (Article XXVIII.), are joined on to the relays, A and B, so that their movements imitate the motions of the tongues of these relays, and thus enable signals to be sent by hand when required. Key, N_2, corresponds to the tongue of relay, B, and key, N_1, to the tongue of relay, A. The switches on the keys shift the relay coils from the tongues of the relays, to which they are connected, on to the levers of the keys; thus the switch of key, N_2, when in the position shown in the figure, connects the "split" of the coils of relay, A, on to the tongue of relay, B; but when moved over to the left, the "split" of A becomes connected to the lever of the key.

As it is very important that proper balance should be maintained on the rheostats, in order that the signals may be properly repeated, means similar to that employed in the fast repeater system are adopted for the purpose. C is a standard relay, whose terminal, U, is connected, through the medium of the bottom bar of the switch, F, with the tongue of relay, B; terminal, D, of the relay, C, is connected to earth through the medium of the second bar of switch, F, and the lower set of resist-

FAST DUPLEX REPEATER.

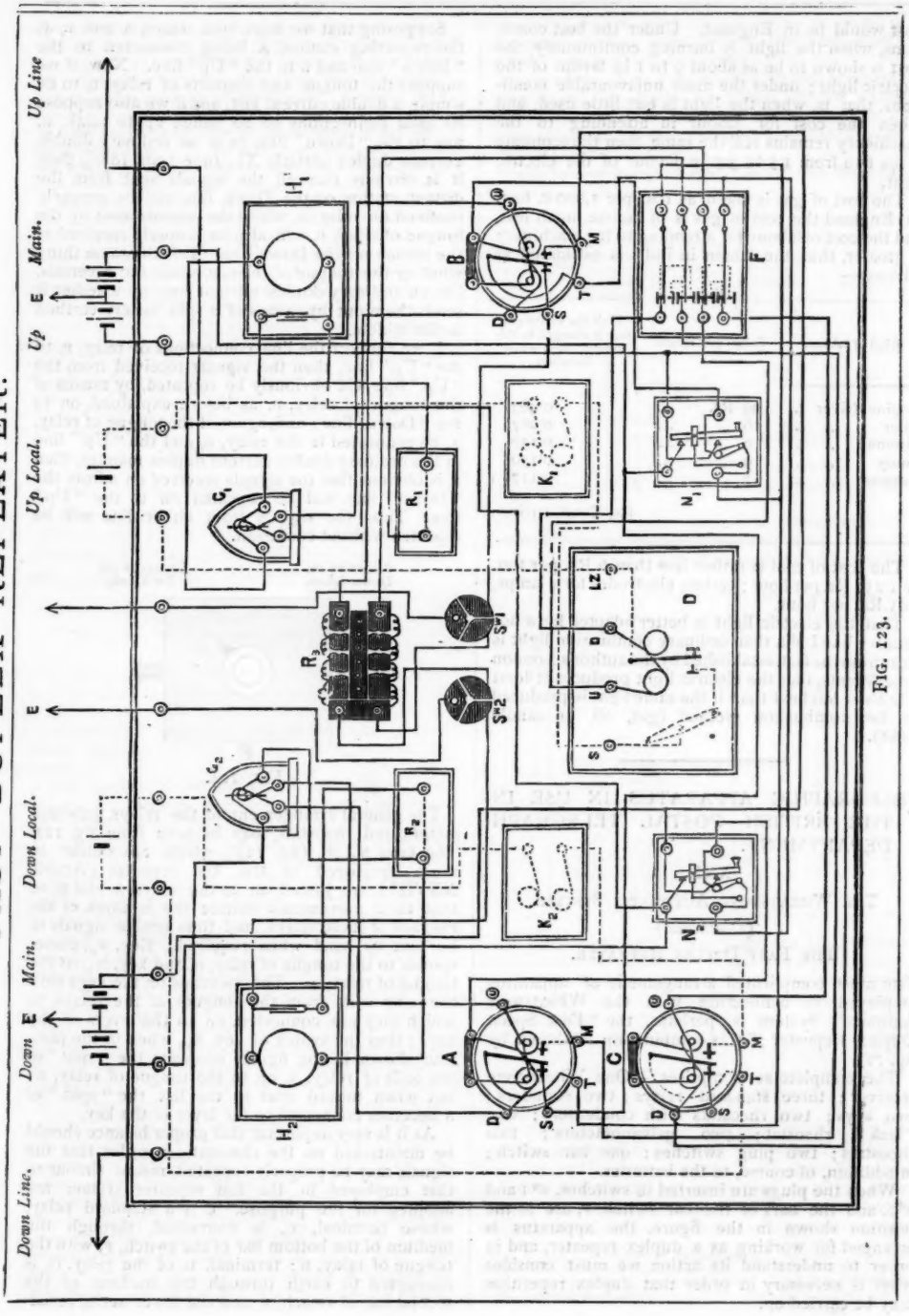


FIG. 123.

ances in the leak resistance box, R_3. Thus, a portion of the current sent out by relay, B, acts on relay, C, and shows whether the signals are being obtained correctly. The movements of the tongue of relay, C, work the local sounder, K_4.

The Wheatstone transmitter, D, is connected with the tongue of relay, A, the circuit being completed through the medium of the top and third bar of the switch, F, and through the upper set of coils in the leak resistance, R_3; thus the currents sent out by relay, A, are registered by means of the Wheatstone transmitter and the local sounder connected to the latter.

If now the bars in the switch, F, be all moved from their top to their bottom contacts, then relay, C, which was originally connected to the tongue of relay, B, now becomes connected to the tongue of relay, A, whilst the Wheatstone transmitter, D, becomes connected to the tongue of relay, B. It will be observed that on making these changes the line and earth connections must be reversed; this the switch accomplishes. By this arrangement, the full speed signals, either to the Up or Down line, can be read off by means of a single Wheatstone receiver. It is never required to read from both lines at the same time, though it is necessary that either line should be able to call the repeater station, and this is provided for by the use of the two sounders.

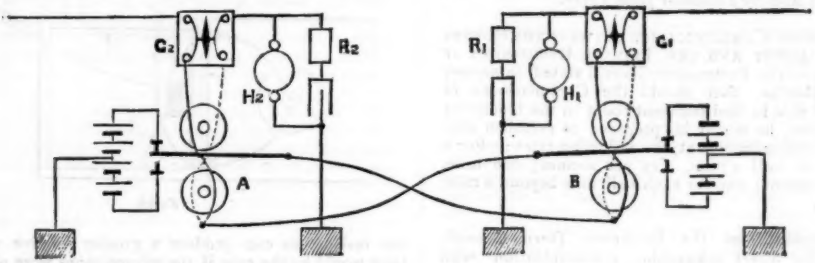


FIG. 122.

Fig. 124 shows an end view of the bar switch box, showing the button by the turning of which the connections become changed.

Notes.

SWAN'S ELECTRIC LAMP.—On Thursday evening there was a large attendance of ladies and gentlemen at the Philosophical Society's rooms, Glasgow, when Mr. Swan again took the opportunity to explain the chief features of his lamp for the benefit of the fair sex, knowing well that if he could but gain their approbation to the introduction of his lamps, success would be his. His remarks were very clearly and plainly stated, and all present were highly delighted. Mr. Swan has been quite lionised during his short stay in Glasgow. We understand that Messrs. D. and G. Graham, of the Telephone Exchange, have become the agents for Scotland for the Swan Electric Lighting Company, and that already they have booked an order to light up the house and well-known colliery belonging to Mr. Watson, of Earnock, besides having obtained promises of several private mansions on Swan's principle. It is stated that 250 candle-power can be obtained for each horse-power expended.

THE INFLUENCE OF THE AURORA BOREALIS OF AUGUST, 1880, UPON TELEGRAPHIC CONNECTIONS.—By Herr Ludewig, of the Imperial German Post-Office.—The author remarks that thunderstorms and the aurora exert an injurious effect, more or less, equally upon telegraphic connections, whether suspended in the air or buried in the ground. The auroral disturbances are not very frequent, but when they occur they extend over a very large portion of the surface of the globe. Electric storms are generally very local, but are injurious by reason of their frequency. A remarkable difference is that the auroral perturbations affect chiefly the longer telegraphic lines, and thunderstorms the shorter ones. The author then gives an account of the intense magnetic disturbance, from the 11th to the 14th of August last. The perturbation extended over the entire northen half of the eastern hemisphere, and even penetrated beyond the equator to Mozambique and Natal. In America brilliant displays of the northern lights are recorded from a number of places; but there is no mention of any interference with the telegraphic service. In Europe the disturbances took the form of strange currents, so called earth-currents, varying in intensity, duration, and direction. In Germany almost all the long lines were thrown out of order from about noon, August 12th. Single characters, and even whole words, were often wanting; and in the Morse instruments the armature occasionally remained fixed, so that unbroken lines appeared on the paper. The needles in the galvanoscopes were deflected, first to one and then to the other side, and often remained from five to ten minutes in a divergent position. The Berlin-Hamburg (underground) and Berlin-Warsaw (above ground) lines were almost unaffected, though the cable from Hamburg to Norway was greatly disturbed. General perturbation was experienced in Britain, France, and Spain. In one of the cables from Marseilles to Algiers strong earth currents were observed, whilst the second parallel cable was unaffected. In Norway correspondence was rendered partially impossible, though the cables to Scotland and Denmark were not hindered. Switzerland was little affected, and Italy and Austria apparently not at all, though the line from Cracow to Warsaw was interrupted from 1·0 to

10·20 p.m., August 12th, in consequence of violent thunderstorms. In Russia the disturbance was felt from the western boundary to the shores of the Pacific. Attention is drawn to the fact that this magnetic storm occurred during the time of the August meteoric shower, and that it coincided with a maximum in the periods of the solar spots.

ON the 24th ult. a paper on "The Future Development of Electrical Appliances" was read before the Society of Arts by Professor John Perry.

TELEPHONIC COMMUNICATION BETWEEN THE HOUSES OF PARLIAMENT AND THE PRIVATE RESIDENCES OF MEMBERS.—The Postmaster-General stated, in answer to Mr. Bourke, that should the Commissioner of Works be able to find sufficient room in the House for this purpose, he would be prepared to establish telephonic communication at the following rates:—For a distance of half a mile, £15 per annum; one mile, £19 per annum; and for each half mile beyond a mile, £4 extra.

PETITIONS from the Inverness Town Council, praying for direct telegraphic communication with London, and from the Wick Town Council for direct communication with Aberdeen, have been presented to the Postmaster-General.

TELEPHONIC SYSTEM WITHOUT CONDUCTING WIRES.—Signor Senlicq d'Ardres communicates an idea suggested by the photophone for obtaining the transmission of sounds without conducting wires. The sounds are emitted by means of a mouth-piece like that of Edison for conveying speech to a distance and to cause them to arrive at a large concave reflector which receives a relatively large proportion of the sound-waves, and concentrates them at its focus, which is occupied by the mouth-piece of a microphonic speaker, rendered much more sensitive by a contact lever with unequal arms. The short arm of the lever corresponds to the vibratory plate of the speaking instrument, and the long arm to the contact of the movable carbon.—*Il Progresso.*

MEASUREMENT OF THE DIFFERENCE OF POTENTIAL BETWEEN TWO METALS IN CONTACT.—It is known that the contact theory of Volta, after being abandoned for a long time in favour of the electro-chemical theory, has been for some time again taken up by physicists, and that they have succeeded not merely in demonstrating that the simple contact of the bodies with each other may develop electromotive force, but even to measure this force, or, what comes to the same thing, the difference of potential between the bodies in contact. According to Signor Pellat, the electromotive force of contact varies according to the physical state of the metallic surfaces. Thus between copper and zinc washed with absolute alcohol the force in question is 0·75 volt.; but between the same metals rubbed with the finest emery paper and then washed with absolute alcohol it is 0·90 volt. The metals generally become more positive as their temperature increases and more negative as it falls. The electromotive force of contact varies likewise with the physical conditions of the air interposed between the two discs.—*Il Progresso.*

MR. GEORGE D'INFREVILLE of New York has patented a method of counterbalancing the effects of the charge current in a duplex telegraph system, by momentarily diminishing the normal resistance in the artificial line simultaneously with the act of charging the main line.

A PATENT (of which we give an illustration) has been taken out in America by Francis Blake for a battery telephone, in which microphones are placed in the two arms of a Wheatstone bridge, so that the variation in

the resistances can produce a greater relative effect than would be the case if the microphones were placed in an ordinary circuit.

ON March 11, in the High Court of Justice, Chancery Division, before Vice-Chancellor Bacon, the case of the Edison Telephone Company *v.* the India-Rubber and Telegraph Works Company was mentioned. This had reference to an action brought for alleged infringement by the defendant company of Edison's patent for *carbon* telephone transmitters. An application was made by the defendants for leave to amend their particulars of objections. Reference was made to several journals to prove prior publication of the invention in this country; amongst others the TELEGRAPHIC JOURNAL for the 15th February, 1877. On behalf of the plaintiff company, it was submitted that the application ought not to be granted, except upon the terms of an order upon the defendant company to pay the plaintiffs' costs in the event of their electing to discontinue the action. His Lordship made the order that the defendant company pay the costs of the application, and the cause to stand over generally, with liberty to the parties to apply to restore it to the paper if necessary; the plaintiff company, however, should have one month instead of six weeks within which to elect to discontinue or not.

ON March 19, before the Master of the Rolls, the case *Re* the Telephone Company (Limited) was heard. This was a petition by the Right Hon. E. P. Bouverie, the owner of 100 shares in the above company, which is in course of voluntary liquidation for the purpose of being amalgamated with the Edison Telephone Company, asking for the removal of the liquidator of the above company, who was also a director in order that certain transactions by the directors of the company, which were alleged to be *ultra vires*, might be investigated by an independent person. Mr. Chitty, Q.C., and Mr. Romer appeared for the petitioner; Mr. Davey, Q.C., and Mr. Kirby for the liquidator; and Mr. Ince, Q.C., for other parties. The Master of the Rolls directed that the petition should stand over generally to allow of a meeting of the shareholders of the company to be called by the liquidator, when the following questions were to be submitted:—First, whether the shareholders desired proceedings to be taken in the name of the company to impeach the transactions; secondly, whether they were willing that proceedings should be taken in the name of the company at Mr.

Bouverie's risk and expense, but for the benefit of the company. The capitalist shareholders were not to vote at such meeting. If Mr. Bouverie objected to take the order in that form the petition was to be dismissed with costs.

CONTRIBUTIONS TO THE THEORY OF THE MAGNETISATION OF STEEL.—By A. Righi.—The measurement of the magnetism took place in the well-known manner, by placing the magnet-bars in a coil in front of the mirror-magnet of a compass, the action being compensated by a second spiral placed behind the mirror and traversed by the same current. The permanent magnetism was determined after opening the circuit, the magnet being approached to a certain distance from the mirror. In this manner the author observed the following facts, which he speaks of as "laws." The permanent magnetism of a bar increases a little if it is surrounded with a metallic covering, the more so the thicker the covering, the shorter and thicker the rod, and the smaller the number of turns in the magnetising spiral. If the circuit is slowly closed and quickly opened a rod inclosed in a metal tube acquires more permanent magnetism than if it lay alongside the tube. If the circuit is closed quickly and opened slowly the reverse rule holds good. A steel bar placed in an iron tube becomes less magnetic if the tube is entire than if it is slit. The difference is the more considerable the feebler the current, and disappears on closing slowly. Magnetism penetrates into a steel rod the more slowly the circuit is closed. (The author has sought to demonstrate this by dissolving away portions of the metal, which completely alters the distribution.) If the circuit is quickly opened the magnetism of the bar is decreased, especially in the superficial layers. Consequently it can remain more strongly magnetised in the interior than in the strata near the surface, or it may show an opposite polarity in the latter. The properties of a bar demagnetised by an opposite current do not always depend on strata magnetised in a reverse manner. They are not formed if the circuit is opened and closed more slowly. These results are referred to the induction currents produced in the mass of the coatings and bars; at the same time, owing to the reciprocal action of the molecules, the internal molecules revolve more slowly. The temporary magnetism of a bar is the greater the more rapidly the circuit is closed. The increase of the temporary magnetism due to rapid closing, as compared with slow closing, is greater when a counter-current acts prior to closing. The temporary moment of a steel bar, owing to a current of a given intensity, is greater if a stronger, but gradually diminished, current is previously allowed to act. The permanent magnetism of a steel bar is the greater the more quickly it is subjected to the action of the current, as, *e.g.*, in an instantaneous closing of the circuit as compared with a slow one. The difference between both results the shorter the wire of the magnetising coil. The permanent magnetism of a steel bar is the greater the more slowly it is withdrawn from the magnetising action, as in opening the magnetising circuit rapidly or slowly. If two equal bars differing in hardness are magnetised simultaneously the decrease of the magnetism from their reciprocal action is greatest in the softer bar. If a circuit is slowly closed and quickly opened the softer bar receives more magnetism, but the harder if it is quickly closed and slowly opened. Hence the displacement of the molecules takes place, *ceteris paribus*, more rapidly in soft steel. If two bars of different thickness are magnetised simultaneously, the thicker one is most affected by their reciprocal action. In case of tubes inserted into each other the opposite results are obtained. If shorter and shorter bars of a given thickness are magnetised the permanent magnetism first decreases to null with decreasing length, and then becomes reversed. The feebler the current the greater the length at which the inversion takes place. With an increasing intensity of the current the reversed magnetism increases first to a maximum, decreases then to null, and finally passes over into normal magnetism. Inversion appears only if the circuit is rapidly opened. In case of quick closing inversion does not appear if the intensity of the current is slight, but it is still manifested on closing slowly. The influence of this kind of closing is the plainer the smaller the number of turns of the magnetising spiral. If on opening the current the bar occasions induced currents in an adjacent metallic mass the polarity either remains inverted, though more feeble, or normal magnetism appears. If a steel disc is magnetised in the direction of one diameter and is then exposed to magnetising force in another direction, the direction of the polarity is displaced further and further with the growing intensity of the second force. The same takes place with the increasing angle of the two directions of magnetisation when the second force exceeds a certain limit. If, on the other hand, the second force is small enough, the displacement decreases with the growth of the angle down to 90°. The angular displacement of polarity by a second force, forming with the first an angle of 90°, is the greater the more quickly the circuit is closed and the more slowly it is opened. If the disc revolves between the magnetising spirals it always retains a certain magnetism which does not correspond to the diameter which lies in the direction of the lines of force on opening the circuit, but is displaced in the direction of the rotation, though to a less degree, the greater the intensity of the current.—*Weidemann's Beiblätter.*

THE Clyde Spinning Company (Glasgow) have introduced the electric light into one of their flats with a view of testing its adaptability to such work. The cotton works at Deanston are about to adopt the electric light.

BEFORE the Royal Society, Edinburgh, on February 21, Prof. Fleeming Jenkin in the chair, Sir William Thomson communicated a paper by Mr. Witkowski on the effect of strain on electric conductivity. A cylindrical brass tube, with a magnet and attached mirror suspended horizontally in the centre at right angles to the axis, was traversed from end to end by an electric current. In its original unstrained isotropic condition the cylinder so conducted the current that the inclosed magnet was unaffected. A couple was then applied in a plane at right angles to the axis, so as to distort the metal tube by a definite twist, thus rendering it æolotropic as regards its electrical conductivity, and giving to the current a spiral set, which was evidenced by the deflection of the suspended magnet. The lines of flow set spirally round in a direction contrary to that of the applied couple—a result in complete accordance with the theory of twists, which requires a lengthening (and therefore an increase of resistance) along spiral lines that set round with the couple and a simultaneous compression (and corresponding decrease of resistance) along lines at right angles to these. Quantitative results were obtained by balancing the electro-magnetic action of the current in the strained tube by means of an external circular movable conductor traversed by a steady current. Sir William Thomson described certain experiments which he had lately made on the effect of moistening the opposing surfaces in a Volta condenser, and of substituting a water arc for a metallic arc in the determining contact. The main features of the paper were, the non-existence of any measurable difference of potential when contact

was made by means of a drop of clean water between opposed polished surfaces of zinc and copper, the effect of oxidising the surfaces in the pure metallic contact experiment, and the exact similarity in the action of dry polished zinc and wet oxidised zinc when opposed to dry copper and brought into contact by a metallic arc.—*Nature*.

THE Central Telegraph-office at Amsterdam is lighted by the Von Hefner-Alteneck system of electric lighting. The result is said to be very satisfactory.

A SUBTERRANEAN cable of 12 wires is being laid between Nancy and Paris. The cable is inclosed in a cast iron tube, with flush boxes every 500 metres.

THE ELECTRIC LIGHT IN THE CITY.—The following details show the arrangements of the electric lighting system which will be carried into operation from the commencement of the present month :—

Name of Contractor.	Length of Circuits. Position of Generator.	Number of Lamps.	Number and Kind of Machines.	Engines.	Horse-power of Engine.	Conductor.
The Anglo-American Electric Light Corporation. (Brush system.)	Single circuit of 20,000 feet. Generator at Vine-street, Lambeth.	32	1 forty-light Brush machine.	Brotherhood or Galloway, one being always in reserve.	Either 28 *indicated*	7 No. 16 B.W.G. stranded.
Siemens Bros. & Co., Limited.	Generators at Swan-lane, Thames-street. The lamp furthest from the generator is distant about ¾ mile.	6 powerful, at an altitude of 80 feet. 28 of about 300 candle-power, at an altitude of about 20 feet. Carbons to last 18 hours.	One machine to each lamp. Two alternate current for the 28 lamps, the latter being divided into 4 groups of 7 lights each, 2 groups to each machine.	2 Marshall & Co.'s., a third by the same makers being always in reserve.	20 *nominal* each.	Copper, covered with gutta-percha, laid in cast-iron pipes, except on London Bridge, where wires lie on parapet.

THE PHOTOPHONE.—Writing to *Nature*, Mr. Herbert Tomlinson says:—"Three years ago, while experimenting on the action of radiant heat and light on the electrical resistance of substances, I was induced to believe that coating selenium with varnish or lamp-black would largely increase its sensibility to light. I therefore annealed a stick of selenium about 2 cm. in length and 5 cm. in diameter, having previously melted into each end a platinum wire, and thus obtained a specimen which, though of very high resistance, was exceedingly sensitive to the action of light. The effect of diffused daylight was tested in the following manner:—The specimen was placed in a glass box and connected directly with two Leclanché cells and a very delicate Thomson's galvanometer, having a resistance of 6,000 ohms; a deflection of, as far as I now remember, about 300 divisions of the scale was produced, and the light was then brought to zero by means of the adjusting magnet; a dark blind which had previously been drawn down was now pulled up, and the result was a deflection of about 100 divisions in the same direction as before. The glass box was placed three yards in front and a little to one side of the window, which was closed, and the sun at the time (about 4 p.m., July, 1877) was on the other side of the house. The selenium was then coated with shell-lac varnish, and about two hours afterwards again tested in the same manner as before, when the light was found to produce a deflection of 220 divisions, or more than twice the previous amount. The action of radiant heat was similar to that of light in the case of this particular specimen, but I have little doubt that *any* specimen may be rendered more sensitive to light by coating it with varnish or lamp-black."

THE Central and South American Cable Company has contracted with the Governments of Costa Rica and the United States of Columbia for a line across the Isthmus of Panama, and a working party has left Vera Cruz to make surveys and enter upon the construction of a line across the Isthmus of Tehuantepec. From thence lines will connect through Nicaragua and Guatemala, opening communications with the entire West Coast.

A PRIZE of £25 has been offered by Mr. James Johnston, of Edinburgh, for an explanation of the nature of electricity; the prize to be awarded by the Congress of Electricians at Paris.

THE PARIS INTERNATIONAL ELECTRICAL EXHIBITION, 1881.—The following letter has been circulated.

SIR,—At the instance of the Society of Telegraphic Engineers and of Electricians, I have undertaken, with the concurrence of M. Berger, the Commissaire-Général of the forthcoming Exposition d'Electricité, to do all in my power to aid the exhibitors in the British section, in the allotment of space, the arrangements for the reception of the exhibits, and the procuring, if required, of tables, stands, or other appliances necessary for the proper instalment of their exhibits. For any actual cash disbursements on behalf of the exhibitors I shall, of course, require to be paid; but so far as my personal services are concerned they will be at your command, free from charge, as are my services, as local honorary secretary in Paris to the Society of Telegraph Engineers and Electricians. I may mention that the Commissaire-Général has promised me his support in these matters, and has kindly intimated his intention of providing me with a suitable office in the building when ready for the reception of exhibits; meanwhile I shall be happy to attend to any communications addressed to me.—I am, Sir, yours obediently,

J. AYLMER.

ELECTRIC LIGHTING.—The Inman Steamship Company's ship, the *City of Paris*, having been fitted with new engines, will shortly commence running to New York. She has also been fitted with the electric light in the steerage, the system employed being the same as that which has given so much satisfaction on board the *City of Berlin*. The whole of the work has been

furnished and applied by the Electric Lighting Supply Company, under the superintendence of Mr. Killingworth Hedges, C.E.

THE TELEGRAPH CLERKS AND THE GOVERNMENT.—On Saturday night two meetings of postal telegraph clerks were held at the Foresters' Hall, Aldersgate-street, the aggregate attendance being about 1,500. Mr. A. S. Coates occupied the chair, and addressed the audience upon the subject of the recent deputation to the Postmaster-General. Mr. Slingo, on moving a vote of confidence in the committee appointed to conduct the agitation, advised the men to be united and prepared for an unfavourable decision with regard to their claims. He stated that great dissatisfaction was felt throughout the country at the manner in which the deputation had been received, and the London committee had had the greatest difficulty in preventing the provincial clerks from striking. It was agreed that a statement should be prepared and issued to the public, and also that a general conference should be called within a limited period to decide upon the course to be adopted in the event of an early and satisfactory reply not being received from the Postmaster-General. Resolutions were also passed pledging the meeting to support any and every action of the committee, and also to act in unison with the provincial staffs, one speaker stating that if those telegraph clerks "struck" it would be the duty of the London men to follow their example. The meeting terminated with the passing of a vote of thanks to Mr. Macliver, M.P., who, with other members of the House of Commons, has been very earnest in his representations to the Postmaster-General upon the subject. A meeting of telegraph clerks was held in Leeds on Saturday evening, at which delegates from various other towns were present. The report of the delegates who waited upon the Postmaster-General on Tuesday was presented, and called forth general condemnation. A resolution was unanimously passed pledging those present to support the Liverpool Committee in any action they may think fit to adopt with reference to the claims of the clerks to be placed upon a proper status as civil servants of the Crown. A similar meeting was held on Saturday evening at Newcastle-on-Tyne. At a meeting held at Bristol on Saturday resolutions were adopted expressing surprise and regret at Mr. Fawcett's conduct, and postponing definite action until the subject had been brought before Parliament on the Post-Office Estimates. The tone of the meeting, however, was distinctly in favour of carrying on the fight to the end. A premature disorganisation of a service so essential to the public was condemned, and it was determined not to take extreme measures until all other measures had failed. But it was quite understood that extreme measures might become necessary, and the Central Committee was requested to call together representatives of the whole service when final action was to be taken. The meeting was very enthusiastic and determined, and numerous telegrams were received in sympathy from different parts of the country.—*Daily News*, March 21, 1881.

THE invention of the telephone is likely to prove a considerable source of profit, if not to the inventors of the same at least to the members of the legal profession. There are many signs of a great commotion in the telephone world, caused either by the ignorance of patent agents of the proper way to draw up a patent specification, or by the promoters of telephone companies not ascertaining the conditions under which they can make use of the articles they supply.

The rights and wrongs of the carbon transmitter question are likely soon to come to the point. Notice has been given of a petition for leave to enter a disclaimer and memorandum of alteration of certain parts of Mr. Edison's patent for "Improvements for controlling by sound the transmission of electric currents, and the reproduction of sounds at a distance." In addition the United Company threaten proceedings against the British Gower-Bell Company for infringement of the said Edison patent, to which the secretary of that company writes:—"In reply to an announcement by the United Telephone Company, the secretary of the Gower-Bell Company states that the value of the allegation that proceedings will be taken for infringing the Edison patent may be measured by the facts that the United Company did commence five actions on that ground, which were withdrawn, and that should legal proceedings be renewed, this company's directors are satisfied that they have a complete defence, and that the positions intended to be taken by this company, as indicated in the prospectus, can and will be maintained."

THE annual amount paid for gas consumed by the public lamps of the City of London is about £14,000. The amount agreed upon for the electric lighting, by way of experiment, of three districts for twelve months, from sunset to sunrise, is £8,060. It is roughly estimated, says the *Citizen*, that the cost of the experiment including the plant, machinery, fixing, replacing, and so on, will be about four times the price now paid for gas; but eliminating these expenses, which would not be recurrent, the cost would only be twice that of gas. In the districts where the experiment is in operation gas will not be used unless the electric light should fail.

A NEW organisation, styled the New York Electrical Society, has lately been organised in that city, having for its object the advancement of the knowledge and uses of electricity. The following officers were elected for the ensuing year:—President, F. W. Jones; Vice-presidents, George B. Scott, Prof. Vander Weyde, Gerritt Smith, W. J. Dealey, George A. Hamilton, and G. G. Ward; Secretary, John W. Moreland; Treasurer, M. Brick. The membership is already quite large, and comprises many of the foremost electricians residing in the vicinity of New York.

AN association of electricians is being formed in Spain.

A TELEPHONE REISSUE.—The Patent Office, after careful hearing, has granted to Mr. E. Berliner, a reissue of his original telephone patent, of January 15, 1878, with several new claims, among which is one that virtually awards to the above author the priority of invention and use of the local battery in conjunction with telephone instruments. Prior to the invention of Mr. Berliner it was necessary to yell very loud in order to make anybody hear at any considerable distance through the telephone, and even then the speaker's voice was heard quite faintly. But now, with this improvement added, the telephone is rendered so sensitive that conversation in whispers may be readily carried on, and the ordinary tones of conversation are delivered by the instrument in the most perfect and admirable manner. Mr. Berliner is entitled to the highest honour for his remarkable invention, which is now used in all parts of the world. The patent is held by the National Bell Telephone Company, of Boston, Mass.—*Scientific American*.

THE latest date for applications for space in the Exposition Internationale d'Electricité is to be April 15th, instead of the 31st ultimo.

Proceedings of Societies.

PHYSICAL SOCIETY.—MARCH 12th.

Sir W. THOMSON in the Chair.

New members—Mr. COLVILLE BROWN, Dr. J. P. JOULE.

COLONEL FESTIN read a paper by Captain ABNEY and nimself, on the absorption spectra of organic bodies. The method of photographing the infra-red region of the spectrum gave better results for absorption than the thermopile. Organic compounds were chosen as giving larger molecules. The apparatus employed consisted of a small Gramme machine driven by a Brotherhood engine, and an electric lamp with a device for shifting the negative pole so as to get the crater on one side of the other carbon point. The image of the positive pole was allowed to fall on the slit of the spectroscope: the light of the arc not being used. Three prisms were used and a camera with a back-swing to it, so as to get a considerable length of spectrum in focus. Maps of the various spectra were made with six inches of the substance examined inclosed in a glass tube. Alcohols, acids, oils, and water were examined, and gave spectra of bands and lines. When hydrogen was absent in the compound there were no lines, and the authors conclude the lines to be due to hydrogen. Oxygen appeared to obliterate the space between two lines and make it a band. The authors hope by this method to detect the radicles present in a substance. They found correspondencies between some lines and lines in the solar map.

Dr. COFFIN said that two kinds of chloroform, apparently the same, produced different physiological results: the method might distinguish between these.

Sir WILLIAM THOMSON thought it might throw light on the ultimate constitution of matter.

Mr. BROWN read a paper on the "Definition of work in Text-books," and gave reasons for preferring that in Rankines' books.

THE SOCIETY OF TELEGRAPH ENGINEERS AND ELECTRICIANS.

AN ordinary general meeting of this Society was held on Thursday, March 24th, Professor CAREY FOSTER, President, in the chair. The minutes of the last general meeting having been read and confirmed, and the list of new and proposed members read, it was announced that the council were making arrangements for issuing invitations to members to meet Professor Helmholtz at a reception to be held shortly.

A paper by Mr. J. Morris, member, local honorary secretary and treasurer for Japan, on "Telegraphs in Japan," was read by the Secretary.

The author commenced by saying that it was only about nine years ago that Japan had become a well-known country. About that time seventy miles of railway were constructed, and iron, gold, and silver mining were actively prosecuted. Good roads were much wanted to enable the resources of the country to be developed. The erection of telegraphs had had a very beneficial effect in enabling insurrections to be quelled.

In 1869 forty miles of line, worked by Breguet's A B C instruments, were in operation. In 1871 a general system was planned out and surveys made, and in one year materials for the construction of 900 miles of line were ordered. Great difficulties were experienced from the hostility of the inhabitants in opposing the erection of the lines. Old timber was at first used for the poles, which perished in about four years or less, but these were replaced by better wood. Cedar was the kind of wood employed most extensively. Iron poles were too expensive. The life of the cedar wood varied according to the soil in which the poles were planted. Tarring the poles was tried with some success, but tar was difficult to obtain. As timber and labour were both cheap it was best to renew the poles from time to time. Boucherising was tried lately with success. Creosoting was too expensive. Since 1871 Morse instruments had been employed on all the lines, the Siemens pattern being adopted. On the longest line a translator was employed, but direct working had been carried on with 80 Daniell cells and with relays wound to 900 ohms resistance. Single needle instruments were used only on railways; but these were being replaced by the Morse except for block working. The insulators were of the Varley double shed pattern fixed on iron brackets, but arms have since been used. Single cup insulators of native manufacture are now used very largely, the standard of insulation being 40,000 megohms. A cable 1,350 yards long was laid across between two islands. A wire stretched across was first tried, but was carried away by the mast of a vessel. Siemens plate dischargers were placed at the ends of the cable. Open wires on poles were laid across some creeks, the poles being protected by massive timber breakwaters; the spans were 450 yards of No. 11 wire.

In 1879 there were 3,929¼ miles of line, and 9,345 miles of wire in working order. In 1871 a school for teaching operators was started; and in 1880 227 of the latter had been appointed and 97 were under tuition. English, French, &c., formed a part of the instruction course.

A difficulty in signalling arose from the absence of a regular alphabet in the Japanese language. Forty-seven signs were employed for the purpose. The maintenance of the lines was such that it was rare for a fault to be of longer duration than one half a day. In ten months there were 153 faults of 6 hours' duration, 85 of 12 hours, 27 of 24 hours, and 21 exceeding that time. The linemen had each charge of about 30 miles of line.

The rice trade had benefited considerably by the telegraph, and owing to the communication it was possible to send food at once to famine-infected districts instead of it being necessary to keep large stores of rice as was formerly the case.

In 1879 the receipts were £108,323, against £101,674 expenses. This was the first year in which the receipts exceeded the expenses. The total number of messages forwarded was 1,272,756, 96 per cent. being Japanese. The tariff was too low at first to prove remunerative. Twenty characters could be sent thirty miles for a penny. Several new cables had recently been laid down. Tests of the wires were taken twice a week with a tangent galvanometer, and Wheatstone bridge measurements for conductivity were also made. The insulation of the lines averaged 1¼ megohms. Spiders were very troublesome in lowering insulation. In 1879 112 ordinary offices were opened and 70 railway offices.

Specimens of telegraph material of native manufacture were exhibited, and notably some copper wire insulated with lacquer alone.

At the conclusion of the paper a short discussion ensued, in which Messrs. Betts, Dresing, and Preece took part, the meeting then adjourned till the 14th April.

New Patents—1881.

962. "Signalling apparatus for railway trains." H. J. HADDAN. (Communicated by H. Ventzke.) Dated March 7.

977. "Improvements in electric and automatic signalling apparatus, for use in the block system and for protecting level crossings on railway aad tramway lines." E. DE PASS. (Communicated by H. Leblanc and E. V. A. Loiseau.) Dated March 8.

978. "Apparatus for operating fog-bells." W. P. THOMPSON. (Communicated by the International Fog-Bell Company.) Dated March 8.

991. "Galvanic batteries." G. F. REDFERN. Dated March 8.

1016. "Veber-meters or devices for measuring and registering the current flowing through conductors." E. G. BREWER. (Communicated by T. A. Edison.) Dated March 9.

1027. "Improvements in electric lamps, candle holders, or candles and apparatus connected therewith." J. A. BERLY. Dated March 10.

1040. "Electric light apparatus." A. A. COMMON and H. F. JOEL. Dated March 10.

1087. "A rotary hawse pipe for light-ships or other moored vessels, for the purpose of keeping submarine telegraph or telephone cables clear of the cable chains when the ship is swinging by tide or force of wind." S. COCKSHOTT and H. M. GOODMAN. Dated March 14.

1094. "A new or improved system of automatic rapid telegraphy and apparatus and materials to be employed therein." B. J. B. MILLS. (Communicated by W. A. Leggo.) Dated March 14.

1097. "Improvements in voltaic batteries, which improvements are also applicable to secondary batteries." J. H. JOHNSON. (Communicated by La Société Anonyme, la Force et la Lumière, Société Générale de l'Electricité.) Dated March 14.

1107. "Electrical bath apparatus." W. R. LAKE. (Communicated by B. Barda.) Dated March 14.

1119. "Telegraphy." S. PITT. (Communicated by O. Lugo.) Dated March 15.

1206. "Improvements in electrical apparatus for automatically recording or registering the times of signals given and received, applicable for use on railways and for other registering purposes." R. H. HARPER. Dated March 19.

1232. "Electric lamps." H. E. M. D. C. UPTON. Dated March 21.

1235. "A new system of electric light, called the pneumo-electric system." G. A. TABOURIN. Dated March 21.

1236. "Improvements in electric lamps, candles, candle holders, and apparatus connected therewith." J. A. BERLY. Dated March 21.

1240. "Armatures for dynamo or magneto-electric machines, electric engines, and motors." E. G. BREWER. (Communicated by T. A. Edison.) Dated March 21.

1257. "Laying telegraph wires." S. PITT. (Communicated by W. B. Espent.) Dated March 22.

1272. "Improvements in the manufacture of cotton-covered wire and in machinery therefor." W. R. LAKE. (Communicated by H. Splitdorf.) Dated March 22.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1880.

2893. "Apparatus for generating electric currents." WILLIAM BULLER FULLERTON ELPHINSTONE and CHARLES WILSON VINCENT. Dated July 13. 8d. Relates to improvements in the dynamo-electric machine for which letters-patent were obtained bearing date 27th January, 1879, No. 332, the object being to render the action of the machine comparatively steady and uniform, and to enable it to produce, when desired, an alternating current. The first of these results is obtained in part by arranging the coils diagonally upon the armature drum. This arrangement insures that when the drum is rotating the coils will so follow each other that one will enter the field before the immediately preceding coil has left that field. A further improvement tending to this end and providing also for the production of an alternating current is to cause a definite proportion of the induced current to circulate through the electro-magnets. Fig. 1 is a longitudinal central section of the machine; fig. 2 is a transverse section of the same taken in the line 1, 2, of fig. 1. A, A, are standards bolted to the bed plate, B, and carrying a fixed shaft, C. To this shaft

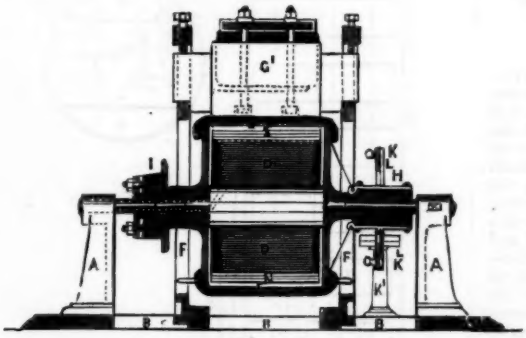


FIG. 1.

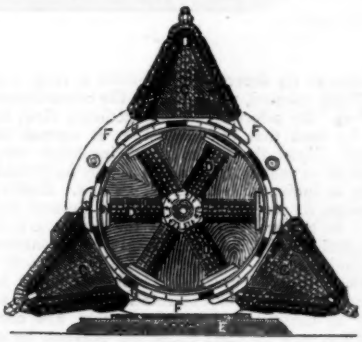


FIG. 2.

are fitted radial plates of soft iron, D, D, constituting a stationary internal magnet. Mounted loosely upon the shaft, C, and surrounding the magnet, D, is a drum, E, constituting an armature. The heads of this drum consist of open discs cast with elongated hubs or sleeves and fitting on to coned shoulders on the shaft, C. The heads are connected to the barrel of the drum

by screws inserted in its periphery or in any other convenient manner. Surrounding the drum are hanks of insulated wire laid diagonally, and so as to cover the periphery of the drum. The way of arranging these hanks and of turning down the terminals of the hanks to the commutator is clearly shown by fig. 3. This armature drum is situate between the side frames, F, F, which are bolted to the bed plate, B, and are secured together by tranverse tie rods. The use of these side frames is to carry the magnets, G, which surround the armature drum and constitute the outside field magnets. These magnets, G, are composed of plates of soft iron having a V-shape in cross section, which shape facilitates the winding on of the insulated wire. The magnets, G, are set radially and concentrically around the armature drum, and are secured to the side frames by transverse bars of wood, G^1, which extend from one side frame to the other. H is the commutator keyed on a sleeve of the armature drum, and I is a band pulley cast with the other sleeve of the drum. Through this pulley rotary motion is imparted to the armature drum for the purpose of setting the machine in action; K is an annular frame supported by pillars, K^1, which stand up from the bed plate. This frame is arranged concentric with the armature drum, and is formed with

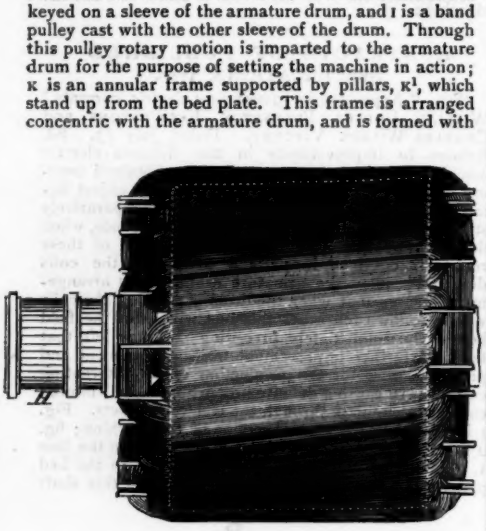


FIG. 3.

a rebate at its inner side to receive a ring, L, correspondingly rebated, which carries the commutator brush holders. By referring to the sectional view, fig. 2, it will be seen that the magnet, D, is formed with six leaves. Upon these leaves the insulated wire is so coiled as to constitute them alternately north and south poles as indicated by the letters, N, S. Similarly the magnets, G, are so arranged as to present opposing poles to the several poles of the magnets, D, as also indicated by the letters, N, S. Both the internal and external magnets are provided with broad pole pieces for the purpose of presenting broad magnetic fields to the coils or hanks of the rotating armature, and the coils of these two sets of magnets are connected together, and to their collecting brushes, by wires in any convenient manner. The inclination of the hanks of the armature with respect to the axis of the drum may vary without material detriment to the object in view so long as the hanks in their revolution follow each other in such manner that a fresh hank will enter the field before the immediately preceding one has left that field. The currents can be made alternating by varying the method of coupling up the commutator brushes.

2989. "Electric pile." MICHEL STAVROU AZAPIS and PANAGIOTIS STAVROU 'AZAPIS. Dated July 22. 2d. This invention relates to an electric pile of constant current and great intensity, and is an improvement or modification of the Bunsen and the Daniell pile. The improvement essentially consists in substituting for the acid or acidulated liquid usually employed in the outer vessel of the pile, a solution in distilled water of any salt, but particularly of cyanide of potassium, or of caustic potash, or of sal-ammoniac in the proportion of about 10 parts of salt to 100 of water. Instead of the salts above indicated, the following vegetable substances can be used in the state of infusion, decoction, or otherwise, namely, sulphate of quinine and quassia amara:—For the sulphate of quinine are employed about 3½ grains (216 milligrammes) of quinine for 555 grains (36 grammes) of water; for the quassia amara the same proportion is adopted as for the salts above indicated. The liquid in the inner porous vessel is the same as in the Bunsen and Daniell piles. (*Provisional only.*)

3043. "Plating iron, steel, &c., with nickel, cobalt, and their alloys." F. C. GLASER. (A communication by Theodor Fleitmann, of Iserlohn, Prussia, Germany.) Dated July 24. 2d. Relates to an improvement on a process previously patented, in which the principal condition for success is the complete exclusion of air from the surfaces to be welded. This is effected by wrapping the metals to be united with thin metal sheets, exposing them to the required heat, and uniting them afterwards by the hammer or by rolling, the metal sheets used as wrappers being subsequently removed from the product by chemicals or in any other suitable manner.

3062. "Automatic fire alarms." R. T. BROWN. (A communication from abroad by Frederick Bogen, of

FIG. 1.

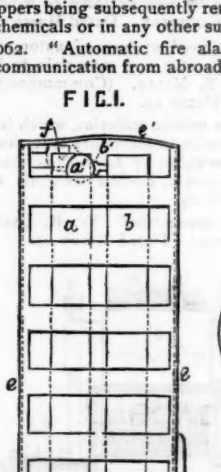
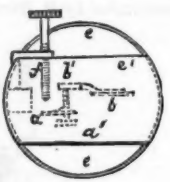


FIG. 2.



Valparaiso.) Dated July 24. 6d. Has for its object improvements in automatic fire alarms. For this pur-

pose, together with other instruments, a "detector" is employed. A side view of the detector is shown by fig. 1, and fig. 2 is a plan of the same. It consists of two straight compound blades *a* and *b*, and each blade is composed of two strips of different metals soldered together in such manner that when heated the compound blade will become somewhat curved. These two blades are placed side by side, and parallel the one to the other. At one end they are attached to insulated supports (upon which are the binding screws, *c*, *c*, for holding the ends of the circuit wires), and at the other end one blade is provided with a contact screw, a^1, by which it makes contact with an arm, b^1, provided upon the other blade. Adjusting screws, *d* and d^1, are also provided to press upon the blades near their attachments to the insulated supports for the minute regulation of the contact between the blades at their other ends. One of the compound blades, viz., *a*, is provided with a sheath of paper, but the other, *b*, is left bare. The whole of these parts are contained within a cage, *e*, which serves to protect them from mechanical injury. e^1 is a turn button for closing the end of the cage after the instrument has been adjusted; e^2 is a stem on the side of the cage to enter a socket conveniently placed to hold the instrument. One or more of these detectors is placed in each room or place where protection may be judged to be necessary, and each is connected with a battery so that an electric current continues to flow through the detector so long as the two blades of the instrument continue in metallic contact. In the circuit with each detector there is an electro-magnet, which serves so to increase the resistance of the circuit as to prevent undue waste in the battery, and the magnet also serves to hold an armature, and when at any time the circuit is broken the movement of the armature closes the circuit of an electric bell, this being the instrument by which the alarm is sounded.

City Notes.

Old Broad Street, March 30, 1881.

DIRECT SPANISH TELEGRAPH COMPANY, LIMITED.—The report of the directors for the half-year ending 31st December, 1880, states that the shareholders will no doubt observe with satisfaction that the accounts for the half-year ending 31st December, 1880, show a balance to the credit of profit and loss of £6,962 6s. 3d. The traffic receipts for the half-year are £1,652 14s. in excess of those for the corresponding half-year of 1879. Both cables have continued during the whole six months, and are now, in perfect condition. The underground line to connect the landing of the Bilbao Cable at the Lizard with the Post-Office at Falmouth has been completed in the most satisfactory manner, and the Company's new offices in the Post-Offices Buildings at Falmouth were opened on 12th January last. The accounts for the construction of this line are not yet complete, but the directors expect that the total cost will only slightly exceed the estimate of £2,500. The directors are happy to be able to state that the arrangements they succeeded in making with the French and Spanish Telegraph Administrations for a reduced rate over the Barcelona Cable, which came into force on 1st January last, have considerably increased the net earnings of that cable. After paying the dividend on the preference shares for the half-year there will remain £4,040 16s. 3d., out of which the directors recommend that the arrears of 10s. per share, amounting to £2,921 10s., still due on the preference shares, be paid, and the balance (£1,119 6s. 3d.) added to the reserve fund, which will then amount to £3,197 18s. 8d. The meeting takes place on Thursday March 31st at the Company's offices.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY, LIMITED.—The directors have issued their report and the accounts of the Company for the year ended 30th September, 1880. It is stated that the total earnings amounted to £110,933 0s. 9d.; amount returned on royalty account, £3,000; total £113,933 0s. 9d., or an increase of £18,199 6s. 4d., as compared with last year. The ordinary working expenses for the year amounted to £33,179 5s. 8d., as against £31,278 15s 4d.; or an increase of £1,900 10s. 4d. The maintenance for the year amounted to £41,849 2s. 3d., as against £24,270 10s. 7d.; or an increase of £17,578 11s. 8d. The debenture interest for the year amounted to £23,120 19s. 6d., as against £17,258 0s. 11d.; or an increase of £5,862 18s. 7d. The increase of ordinary working expenses is made up mainly of legal charges. The increase of expenditure on maintenance account arises from the fact that two ships had to be employed to get the system into good working order, and afterwards it became necessary to bring the *Norseman* home for repairs, and with a view to her return with more cable. The additional steamer *International* was finally discharged in July last; the heavy payments under this head in Abstract "B" then ceasing. Deducting the above expenses from the revenue there remains a balance of £35,904 12s. 10d., plus return royalty account, £3,000; together £38,904 12s. 10d. The interest on the A, B, and C debentures amounts to £23,120 19s. 6d., leaving a balance of £15,783 13s. 4d. against this has to be placed £3,967 6s. 11d., balance of renewal account brought forward from last year, and £10,300 15s. 9d. rebate on former issue of C debentures, leaving £1,515 10s. 8d. to be carried forward to the current year. The C debentures had to be withdrawn from circulation, and the rebate still standing to debit account, under the advice of the auditor, to be made a special charge against the earnings of the year. It is a source of some satisfaction to the board that the exceptional expenses of the year, amounting in the aggregate to £31,846 14s. 4d., have all been met out of revenue. The insertion of the sheathed cable, as already reported, has considerably improved the working of the line, and during the past year the interruptions have been less frequent. Arrangements are being made for the shipment of the remaining 200 miles of sheathed cable to Brazil, and the directors hope that as this is substituted for the deep sea type, the lines will continue to work with increasing efficiency. The directors regret to state that the competition of the Brazilian Government land lines still continues. The representations of the board conveyed through the secretary, who was sent to Brazil last year, were, however, favourably received, and he succeeded in obtaining the appointment of a special Commission to determine the question. A change of government unfortunately occurred, and the Company's petition was thrown out, but the directors are using every effort to obtain a just and favourable decision. The board can only reiterate their formerly expressed opinion that the best means to meet the competition, and to promote the Company's prosperity, is to keep the lines in an effective state. Since the interim meeting in June last, it has been incumbent upon the board to commence actions for the recovery of large sums of money, which they are advised were improperly expended in the promotion of this Company and the Great Western Telegraph Company. The action is now about to be entered for trial, and is expected to be heard shortly. In the meantime, the matter being *sub judice*, discussion would be undesirable and improper. The directors therefore, acting under the

advice of counsel, have decided to defer, for the present, the holding of the annual meeting. Any information, however, which may be desired as to accounts, &c., will be afforded by the officers of the Company. Sir Edward Watkin, Bart., M.P., and Messrs. Cross, Mendel and Cooke have retired from the direction; the vacancies thus created have been filled by the election of Messrs. Earle, Wood, Goodsall, and Sir Henry Drummond Wolff, G.C.M.G., K.C.B., M.P., the latter gentleman having accepted the position of chairman of the Company. In reference to the cable of the Central American Telegraph Company between Para and Demerara the board have felt that, looking at the large amount standing to the Company's credit in the balance sheet on that account, an effort should be made to insure a thorough examination of the state of the cable with a view to its repair should such examination show this to be advisable. Arrangements have therefore been made for a careful survey of this property. The A and B debentures which matured on 1st August last were duly redeemed, and the shareholders are aware that in March of last year the directors, with their sanction, created £200,000 A debentures, and £250,000 B debentures, redeemable on the 2nd February, 1910, by means of an accumulative sinking fund, and annual drawings, commencing in 1890; power being also given for the issue of a furthur sum of £50,000 B debentures, both classes of debentures bearing 6 per cent. interest. The repairing steamer *Norseman*, completely repaired, furnished with new engines, boilers, &c., left for Brazil in June, fully equipped in every respect. The repairs were effected at a moderate cost, the directors having been able to make the contract at a time when labour and materials were cheap. The ship took out 200 of the 400 miles of cable ordered from the Telegraph Construction Company, and has since been engaged in several repairing expeditions, giving entire satisfaction.

THE Eastern Telegraph Company (Limited) have declared a dividend of 2s. 6d. per share, free of income-tax, for the quarter ended December 31, 1880, and one of 3s. per share on the 6 per cent. preference shares, less income-tax, for the quarter ended March 31, 1881. The half-yearly interest on the 6 per cent. debentures will be paid on April 15 next, at the banking-house of Messrs. Glyn, Mills, Currie, and Co.

THE Eastern Extension Company give notice of final dividend of 2s. 6d. per share, with bonus of 1s. per share, making 6 per cent. for the year 1880, carrying forward £69,178.

AT the meeting of the Hamburg-Heligoland Telegraph Company the dividend for 1880 was fixed at 15 marks or 14s. 7d. per share.

THE dividend of the German Union Telegraph Company for the year 1880 will be 30 marks or 10 per cent., 12 marks or 4 per cent. of which was paid in January last.

UNDER date the 16th March it was notified that the Brest-St. Pierre cable of the Compagnie Française was interrupted close to St. Pierre. The *Pouyer-Quertier* s.s. was to leave at once to effect the necessary repairs.

THE *Daily News* of March 21, in recommending reduced tariff for Anglo-American telegrams, states that no fewer than five new competing cables are threatened from various quarters.

A REUTER'S telegram of March 15 mentions that the Asiatic Cable Bill passed on that date the second reading in the Dominion House of Commons.

THE Globe Telegraph and Trust Company gives notice that interim dividends for quarter ending April 18, 1881, of 3s. per share on the preference shares, being at the rate of 6 per cent. per annum; and 2s. 6d. per share, being at the rate of 4 per cent. per annum, on the ordinary shares.

The following are the final quotations of telegraphs:—Anglo-American, Limited, 57¼-57⅜; Ditto, Preferred, 86-87; Ditto, Deferred, 29-29½; Black Sea, Limited, ——; Brazilian Submarine, Limited, 10⅛-10⅜; Cuba, Limited, 8⅞-9¼; Cuba, Limited, 10 per cent. Preference, 16¼-16⅝; Direct Spanish, Limited, 3¾-4¼; Direct Spanish, 10 per cent. Preference, 14-15; Direct United States Cable, Limited, 1877, 10⅜-11; Scrip of Debentures, 102-104; Eastern, Limited, 9⅛-9⅜; Eastern 6 per cent. Preference, 12⅛-12⅜; Eastern, 6 per cent. Debentures, repayable October, 1883, 104-107; Eastern 5 per cent. Debentures, repayable August, 1887, 102-104; Eastern, 5 per cent., repayable Aug., 1899, 102-105; Eastern Extension, Australasian and China, Limited, 10⅛-10⅜; Eastern Extension, 6 per cent. Debenture, repayable February, 1891, 108-111; 5 per cent. Australian Gov. Subsidy Deb. Scrip, 1900, 104-106; Ditto, registered, repayable 1900, 104-106; Ditto, 5 per cent. Debenture, 1890, 102-104; Eastern and South African, Limited, 5 per cent. Mortgage Debentures, redeemable 1900, 101-103; Ditto, ditto, to bearer, 101-103; German Union Telegraph and Trust, 11-11½; Globe Telegraph and Trust, Limited, 6¼-6½; Globe, 6 per cent. Preference, 12⅛-12⅜; Great Northern, 11¼-11½; 5 per cent. Debentures, 103-106; Indo-European, Limited, 26½-27½; London Platino-Brazilian, Limited, 6¼-6½; Mediterranean Extension, Limited, 2¾-3; Mediterranean Extension, 8 per cent. Preference, 10-10½; Reuter's Limited, 10½-11½; Submarine, 270-290; Submarine Scrip, 2¼-2⅜; Submarine Cables Trust, 99-102; United Telephone Company, ——; West Coast of America, Limited, 4⅜-4½; West India and Panama, Limited, 1⅛-1¼; Ditto, 6 per cent. First Preference, 6¼-6½; Ditto, ditto, Second Preference, 5¼-5½; Western and Brazilian, Limited, 8⅛-8¼; Ditto, 6 per cent. Debentures "A," 103-107; Ditto, ditto, ditto, "B," 98-102; Western Union of U. S. 7 per cent., 1 Mortgage (Building) Bonds, 122-127; Ditto, 6 per cent. Sterling Bonds, 101-104; Telegraph Construction and Maintenance, Limited, 31½-32; Ditto, 6 per cent. Bonds, 105-108; Ditto, Second Bonus Trust Certificates, 3¾-4; India Rubber Company, 18½-19; Ditto, 6 per cent. Debenture, 103-106.

TRAFFIC RECEIPTS.

NAME OF COMPANY.	FEBRUARY.		INCREASE OR DECREASE.
	1881.	1880.	
	£	£	£
Anglo-American.....	49,180	40,830	Inc. 9,350
Brazilian Submarine...	15,104	13,517	Inc. 1,587
Cuba Submarine	2,900	3,140	Dec. 240
Direct Spanish	1,876	...	...
Direct United States...	* 16,390	...	...
Eastern	46,463	44,591	Inc. 1,872
Eastern Extension	28,021	25,190	Inc. 2,831
Great Northern	16,880	14,160	Inc. 2,620
Indo-European	...	...	...
Submarine	...	...	...
West Coast America ...	...	1,300	...
Western and Brazilian	10,169	...	...
West India	4,320	5,488	Dec. 11,68

* Receipt in January, £16,180.